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The high-rise building database and its use as a basis for classifying tall building structural systems

Cynthia T. Bruno
Lehigh University

Bruno, Cynthia T.

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by
Cynthia T. Bruno

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This thesis is accepted and approved in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering.

5 May 98

Date

Dr. Lynn S. Beedle, Thesis Advisor

Dr. Le-Wu Lu, Department Chairperson

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ABSTRACT

This research project might be considered an extension of an investigation performed some years ago (Falconer and Beedle, 1984). The original study, entitled "Classification of Tall Building Systems," was motivated by the need for a proper and consistent reference to tall buildings and their systems. Advancing technologies have amplified this need tremendously. If a proper classification scheme is established, then the overall response of a particular system can be studied. The current project takes this factor into account in order to modify the original classification for structural systems and apply it to the High-Rise Buildings Database.

A description of the Council's HRBD is also given, noting the significant value of this remarkable resource. Through literature review and interacting with members of academia and industry, a tall building structural systems classification has been suggested. Its essence is four primary systems: cores, frames, tubes, and walls together with combination (hybrid) systems (those for which no one primary systems is dominant). The most appropriate and commonly used subsystems are identified.

Though many problems arose, such as the required level of detail or overlap between categories, the scheme provides a framework to describe structural systems for tall buildings. It is simple enough to be applied to the HRBD and the tall building survey form. Yet, it is detailed enough to enable a distinction to be made between different types of major systems.

1. INTRODUCTION

For the past three years, the writer has been extensively involved in working with the High-Rise Building Database (HRBD) at the Council on Tall Buildings and Urban Habitat (CTBUH). In maintaining this large collection of information, she observed some inconsistencies. The absence of a uniform structural systems classification seemed to be the most critical issue. This observation sparked her initial interest to further explore this topic.

1.1 RESEARCH PROJECT BACKGROUND

This research project might be considered an extension of an investigation performed some years ago (Falconer & Beedle, 1984). The original study, entitled "Classification of Tall Building Systems," was motivated by the need for a proper and consistent reference to tall buildings and their systems. Advancing technologies have amplified this need significantly. The current project takes this factor into account in order to modify and expand the original classification for structural systems and apply it to the HRBD.

1.2 OBJECTIVES

The objectives of this research project are as follows:

(1) to classify the primary lateral and gravity load resisting systems of tall buildings;

(2) to provide a detailed description of the HRBD;

(3) to implement this classification scheme into the Council's HRBD;

(4) to identify the increased capabilities of the enhanced HRBD.

1.3 SCOPE AND APPROACH

Wind loads, seismic excitations and gravity forces are three of the primary considerations in the design of tall buildings. System-by-system comparisons must be easily accessible to the engineer. Correlation between a particular lateral and gravity load resisting system and certain design aspects, such as building stories, material weight, aspect ratios, seismic zone, or soil conditions, provide valuable information for architects and engineers in the various design stages.

Consequently, this investigation exclusively focuses upon the primary lateral and gravity load resisting systems of tall buildings. This topic directly relates to the writer's background and experience with the HRBD. In addition, since the Council is undertaking an effort to improve the HRBD, it seemed appropriate to pick a system which could directly enhance this database.

This study includes buildings completed or currently under construction. Excluded are unbuilt and proposed buildings. In particular, the lateral and gravity load resisting systems of buildings greater than approximately ten stories are considered.

The following procedure was used with the hope that it would lead to a consistent and effective classification system.

(1) Examine the original research findings (Smith and Coull, 1991, Taranath, 1988, Falconer and Beedle, 1984);

(2) Gather literature and review the existing terminology;

(3) Review the HRBD and project description files for examples;

(4) Formulate a list of all lateral and gravity load resisting systems mentioned in all sources;

(5) Study the characteristics of the lateral and gravity load resisting systems;

(6) Develop a general classification scheme;

(7) Generate a discussion with members of the Structural Systems Committee 3;

The principal sources of information for this study were assembled from literature located in the Council Headquarters Library, Fritz Engineering Laboratory, and Fairchild-Martindale Library. The Council's sophisticated HRBD and its associated project description files provided detailed information about a variety of tall buildings.

Besides gathering literature, personal correspondence provided insight to this research topic. The Structural Systems Committee (3) of the Council on Tall Buildings and Urban Habitat played an indispensable role through its important recommendations. In fact, an e-mailing list was established to stimulate a fast-paced discussion and to provide a forum for debating the issue. Experience the writer gained in working with the HRBD at Council Headquarters has been of great value as well (Beedle, D., 1995).

2. HIGH-RISE BUILDING DATABASE

2.1 BRIEF HISTORY

For over twenty-five years, the Council has gradually collected tall buildings data through its Monographs, conferences, congresses, proceedings, reports and both formal and informal surveys. Twenty years ago, the Council set forth a strategy to create a world-wide listing of tall building information. An international tall building survey was conducted. The Council collected information on approximately 4500 buildings world-wide as a result of this survey. Tables 2.1 and 2.2 show the original typical survey forms. Note that the original form requests information regarding structural systems (Table 2.1).

The large volume of information received as a result of the survey was recorded in a computerized format using a FORTRAN program. The compiled data formed the book *Tall Buildings of the World* (CTBUH, 1986). This title, along with recorded building data from various Council publications, sparked the beginning of a computerized inventory of tall building information. Some years later, the FORTRAN tall building input files were merged with the tall building data collected from Council publications. This compilation of information formed an early version of the current Macintosh-based HRBD.

Today, the HRBD is an impressive array of data which covers over 7200 buildings. It is the largest database of its type in the world with information about projects from six different continents, 88 countries and 768 cities (Table 2.3). The project data continues to be gathered and supplied by members and representatives of the Council on Tall Buildings and Urban Habitat who are world leaders in the fields of research, industry, and education.

Additional sources include the professional specialists, newspaper clippings, magazine articles, textbooks, the media, hobbyists, and the internet.

2.2 DOCUMENTED PROJECT DETAILS

Throughout the years, the type of information collected within the database has been gradually expanded. As shown in Figs. 2.1 and 2.2, the current database layout accommodates the essential project details. Each item collected in the database is listed and described for clarity.

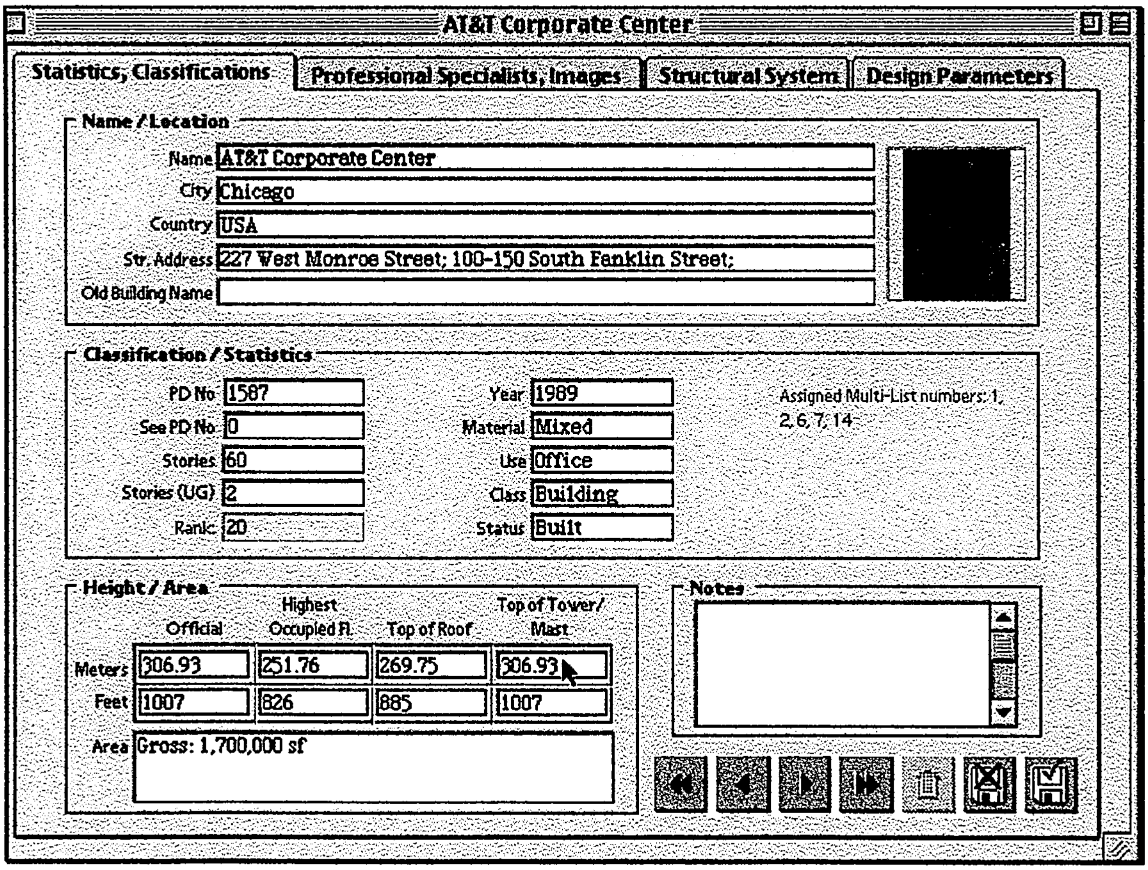


Fig. 2.1 High-Rise Buildings Database Record Layout - Statistics, Classification

Name: The official project name;

City: The city in which the project is located;

Country: The country in which the project is located;

Street address: The street address(es) may be included in this field;

Former building name: When applicable, the structure's previous name is recorded;

PD: The project description number corresponding to a project's vertical file which contains detailed project information;

See PD: The cross reference number associating one PD file with another PD file;

Stories: The number of stories, if applicable;

Stories (UG): The number of under ground stories;

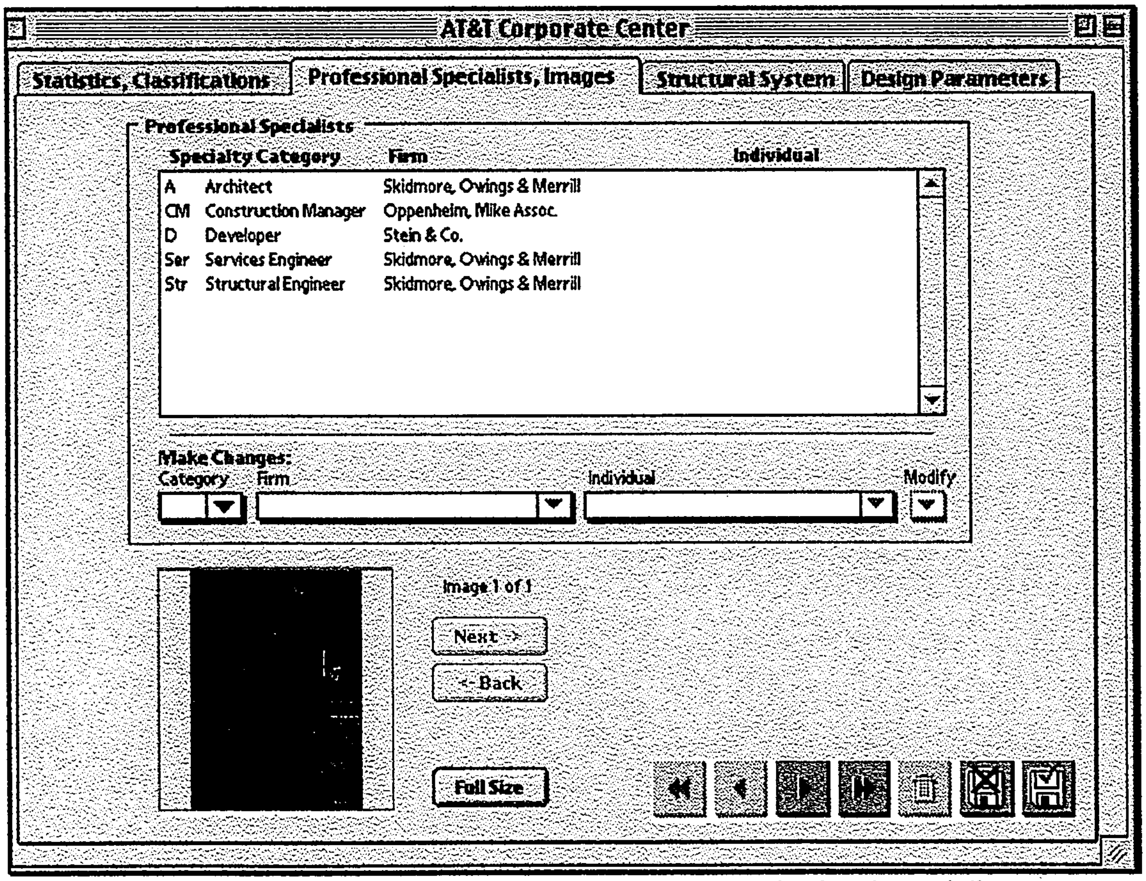


Fig. 2. 2 High-Rise Buildings Database Record Layout - Professional Specialists, Images

Rank: Ranking is determined by height to the structural top of the building, as defined by the Council (see official height definition). If there is a tie, the building with the larger number of stories achieves the higher ranking. If a tie still remains, the building that was completed first is ranked higher. Should a tie still exist, the buildings are ranked alphabetically. As mentioned, only buildings that are complete or that have at least been structurally topped-out are ranked. The Council ranks the tallest 500 buildings (CTBUH, 1998).

Year: The year in which construction of the building was officially completed. If a project is presently under construction, the format "UC99" is used. This notation, "UC99," designates a building under construction expected to be completed in 1999. A similar format is utilized for proposed projects except "UC" is replaced by "PR."

Material: Indicates the main type of material used within a project. As shown in Fig 2.3, the common types are steel, concrete or mixed. For quality control, these common options are provided within a pop-down menu. When another material not listed is required, the pop-up menu can be canceled and the correct material entered manually.

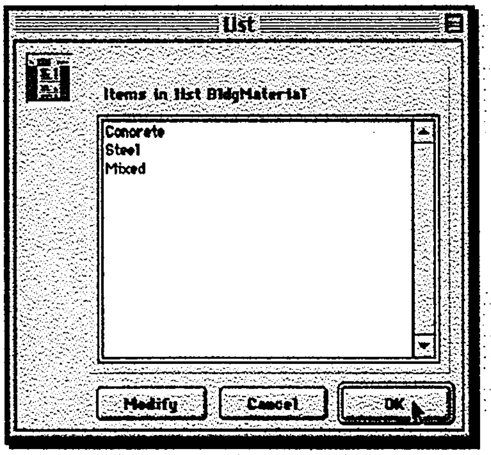


Fig. 2. 3 Project Materials

Use: Designates major use such as office, residential, hotel or multiple use. A pop-up menu, similar to that for materials, is provided to ensure quick and accurate data entry (Fig. 2.4). Again, to input a project use not listed in this pop-up menu, cancel the menu and manually type in the appropriate use. A more complete description of all building uses is found in Table 2.3A (CTBUH, PC-1, 1981).

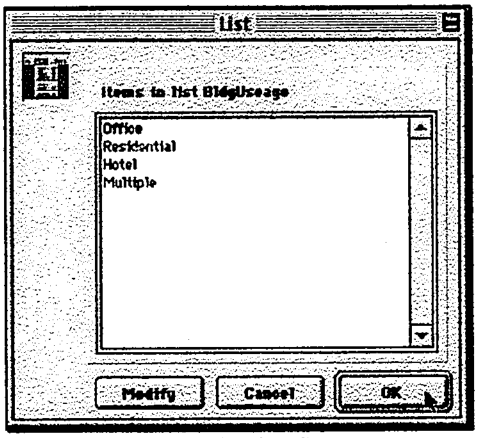


Fig. 2. 4 Project Uses

Class: This term refers to the actual type of project entered into the database. As shown in Fig 2.5, the HRDB does not exclusively contain facts on tall buildings. Other projects, such as towers, and complexes or urban developments are included as well. Each type is defined below:

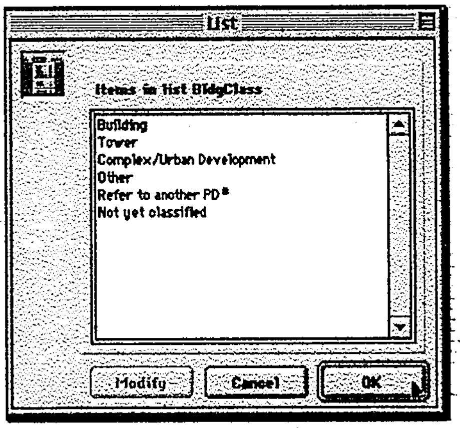


Fig. 2. 5 Project Classes

Building: A building is considered to be a structure that is designed for residential, business, or manufacturing purposes. An essential characteristic of a building is that it has floors. A "tall building" is not necessarily defined by its stories or its height. The important criterion is whether or not the design, use, or operation of the building is influenced by some aspect of "tallness" (CTBUH, 1998). The Council solicits information on buildings of ten or more stories. Likewise, the HRBD primarily lists buildings of ten or more stories.

Tower: A tower generally does not contain stories. This definition is currently under review by members of the HRBD Committee S14 via an e-mail discussion forum.

Complex/Urban Development: This class encompasses projects which consists of a number of buildings. It may also refer to the development of a neighborhood or part of a city, rather than a specific complex.

Other: Assorted projects including, but not limited to, bridges, ships, or roadways fit into this class.

Refer to another PD#: This class appears by default if the record is cross-referenced to another PD file.

Not yet classified: Some project types have not yet been classified. Generally, the information is incomplete or does not provide a clear description of the exact nature or class of the project.

Status: Eight different project status types are distinguished within the HRBD (Fig. 2.6). The details of each are provided as follows:

Built: The project has been completed.

Under Construction: The project is currently under construction and *has not* reached its projected height. Buildings of this status are *not* ranked.

Fig. 2. 6 Project Status

Topped-Out - Under Construction.: The project is currently under construction and *has* reached its projected structural height. Buildings of this status are ranked.

Proposed: The project has been proposed, but construction has not yet commenced. Buildings of this status are *not* ranked.

Future Vision: The unbuilt project is a "dream" of the future. This usually includes unusual concepts or projects of unimaginable proportions.

Unbuilt: Projects that will not be constructed are classified as unbuilt.

Razed/Destroyed: The project has been physically destroyed or demolished.

Not Verified/In Dispute: The project status may not be explicitly clear or stated.

Assigned Multi-List Number: This is a cross reference number, or multi-list number, (ML) indicating that more information about a particular project is available in Report 910.14.

Official Height: The official height, or height to structural top, of a building or tower is measured from the sidewalk level of the main entrance to the structural top of the building or tower. This includes spires, but does not include television antennas, radio antennas, or flag poles. Height is listed in both English and SI units and is rounded to the nearest integer. This official height is also the criterion used by the Council in determining ranking of buildings completed or structurally topped-out.

Other Measures of Height: In an effort to reflect aspects of the statistical height of a building, additional information is recorded when available. As graphically depicted in Fig. 2.7, three supplemental height measurements exist within the HRBD. These measurements also begin at the sidewalk level of the main entrance of the building:

To Structural Top: Height to the structural top of the building (the Council's official criteria as defined above);

To Highest Occupied Floor: Height to the floor of the highest occupied floor of the building. The definition of highest occupied floor is presently under review by members of the HRBD Committee S14.

To Top of Roof: Height to the top of the roof;

To Tip of Spire/Antenna: Height to the tip of spire, pinnacle, antenna, mast, or flag pole.

In many cases, the height of a building is supplied to the Council using only one unit of measure (either English or SI units). Based on the exact value of the unit supplied (feet or meters), the other unit's value is calculated and then rounded to the nearest integer. Due to the accuracy in its smaller unit of measure, feet are used in the final determinant in ranking a building's height.

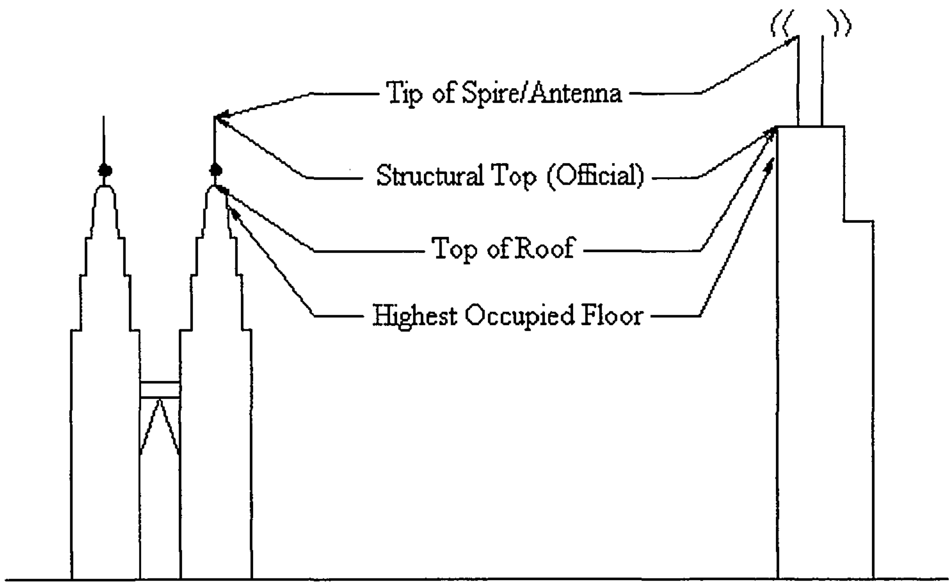


Fig. 2.7: Height Criteria

Area: Different structure areas, such as net, gross, office, or retail may be listed.

Notes/Description: This entry box contains miscellaneous information that may include a significant event, award, or general comment about the structure.

Professional Specialists: Information about the major professional specialists involved with each project are recorded when available. The architect(s), construction manager(s), elevator supplier(s), developer(s), structural and services engineers are provided on the pull-down menu (Fig 2.8). The name of the firm is then entered. Another pull-down menu will appear. The desired firm may be selected from the pull-down menu. Otherwise, enter the firm to the database. The "create a new category" selection is in development and not yet functioning. Therefore firms associated with professions outside the six mentioned cannot currently be entered into the system. However, the information about these additional firms may exist in the PD file.

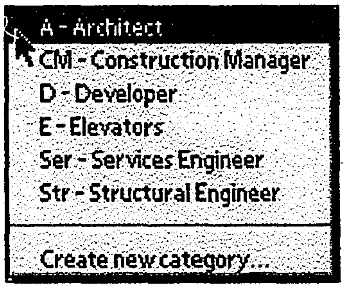


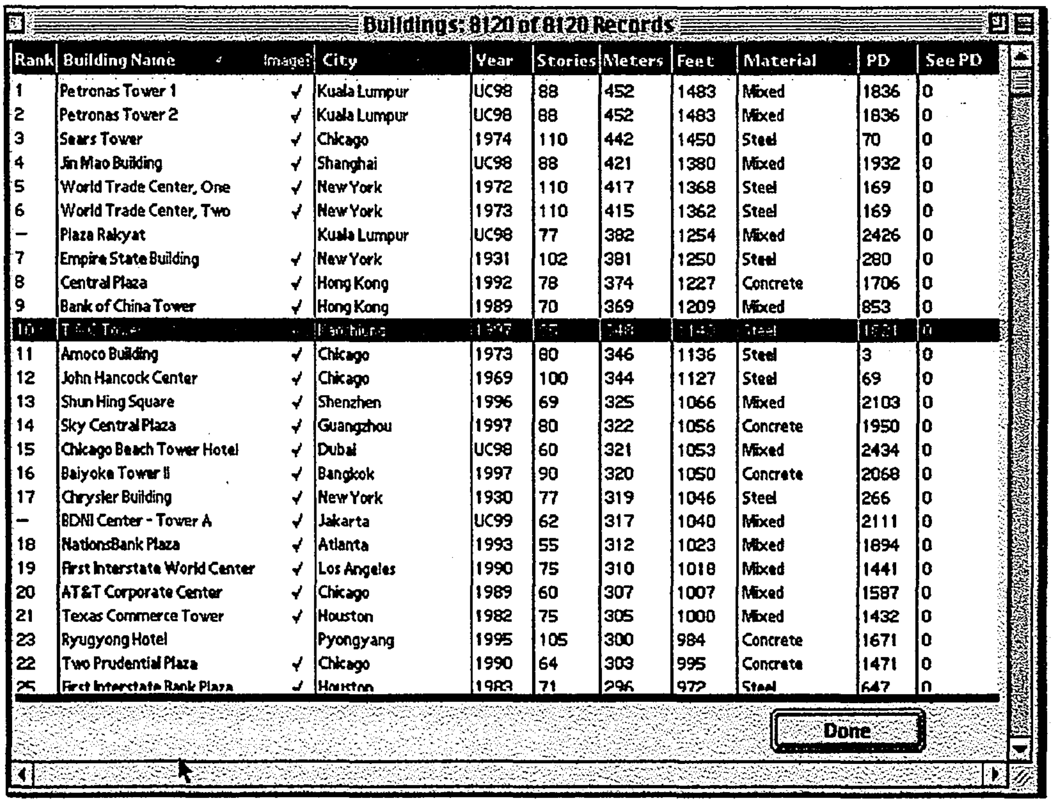
Fig. 2. 8 Professional Specialists

Image: A photo of the project is incorporated into the record when available. More than one image may exist for any particular project.

Structural systems: A description of the main lateral and gravity load resisting systems are provided according to the Council classification scheme as developed within this thesis.

2.3 FEATURES

The user-friendly environment of the HRBD makes exploring this large collection of data an easy operation. Five main menu items provide the user with a diverse array of powerful tools. These principal items, File, Enter, Search, Sort and Selection, are located at the top of the record display screen (Fig. 2.9). When selected, a main menu will reveal various options in the form of a pop-up selection list. Each of these main menu options are described in the subsequent subsections.



Buildings: 8120 of 8120 Records

Rank	Building Name	Image?	City	Year	Stories	Meters	Feet	Material	PD	See PD
1	Petronas Tower 1	✓	Kuala Lumpur	UC98	88	452	1483	Mixed	1836	0
2	Petronas Tower 2	✓	Kuala Lumpur	UC98	88	452	1483	Mixed	1836	0
3	Sears Tower	✓	Chicago	1974	110	442	1450	Steel	70	0
4	Jin Mao Building	✓	Shanghai	UC98	88	421	1380	Mixed	1932	0
5	World Trade Center, One	✓	New York	1972	110	417	1368	Steel	169	0
6	World Trade Center, Two	✓	New York	1973	110	415	1362	Steel	169	0
–	Plaza Rakyat		Kuala Lumpur	UC98	77	382	1254	Mixed	2426	0
7	Empire State Building	✓	New York	1931	102	381	1250	Steel	280	0
8	Central Plaza	✓	Hong Kong	1992	78	374	1227	Concrete	1706	0
9	Bank of China Tower	✓	Hong Kong	1989	70	369	1209	Mixed	853	0
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	348	[illegible]	Steel	[illegible]	0
11	Amoco Building	✓	Chicago	1973	80	346	1136	Steel	3	0
12	John Hancock Center	✓	Chicago	1969	100	344	1127	Steel	69	0
13	Shun Hing Square	✓	Shenzhen	1996	69	325	1066	Mixed	2103	0
14	Sky Central Plaza	✓	Guangzhou	1997	80	322	1056	Concrete	1950	0
15	Chicago Beach Tower Hotel	✓	Dubai	UC98	60	321	1053	Mixed	2434	0
16	Baiyoke Tower II	✓	Bangkok	1997	90	320	1050	Concrete	2068	0
17	Chrysler Building	✓	New York	1930	77	319	1046	Steel	266	0
–	BDNI Center - Tower A	✓	Jakarta	UC99	62	317	1040	Mixed	2111	0
18	NationsBank Plaza	✓	Atlanta	1993	55	312	1023	Mixed	1894	0
19	First Interstate World Center	✓	Los Angeles	1990	75	310	1018	Mixed	1441	0
20	AT&T Corporate Center	✓	Chicago	1989	60	307	1007	Mixed	1587	0
21	Texas Commerce Tower	✓	Houston	1982	75	305	1000	Mixed	1432	0
23	Ryugyong Hotel		Pyongyang	1995	105	300	984	Concrete	1671	0
22	Two Prudential Plaza	✓	Chicago	1990	64	303	995	Concrete	1471	0
25	First Interstate Bank Plaza	✓	Houston	1983	71	296	972	Steel	647	0

Fig. 2.9 HRBD Main Menu Features

1 File Menu

The file menu provides four basic functions: re-ranking, exporting, printing and quitting (Fig 2.10). Each of these functions are detailed below:

Re-rank: This tool assigns an order, or rank, to the top 500 buildings according to the criteria defined in Section 2.2.

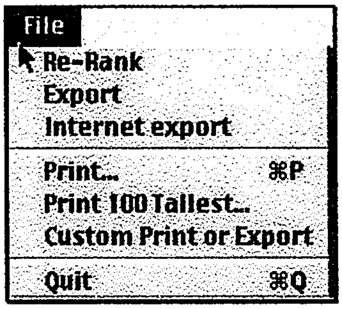


Fig. 2.10 File Menu

Export: This command translate the selected data into a text file. This text file may then be used in other computer applications such as a word processor or a spread sheet.

Internet Export: This pre-defined routine is similar to the regular export command mentioned except that the file format is compatible with the internet.

Print...: This feature prints the selected records displayed in a variety of available formats as shown in Fig. 2.11. Note that a shortcut key combination , "command N", is given for convenience. Tables 2.4-2.8 show examples of each pre-defined print report available.

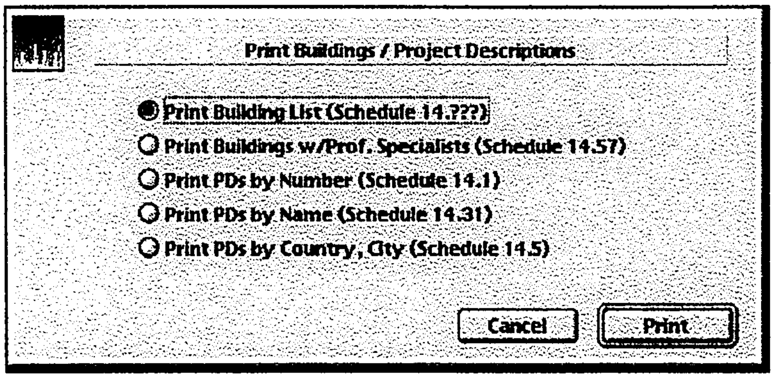


Fig. 2.11 Pre-Defined Print Reports

Print 100 Tallest…: Council report 910.9, *The 100 Tallest Buildings in the World*, is printed periodically to reflect the most up-to-date listing of the 100 tallest buildings world-wide (CTBUH, 1998). Related statistics and data are automatically printed by applying this specialized print command. The report is included in Table 2.9.

Custom Print or Export: This option enables the user to create unique printed reports or exports suitable to their specific needs. Most of the project data fields collected can be used as variables within the custom prints or exports.

Quit: This item exits the database. Its shortcut key sequence is "command Q."

2 Enter Menu

As depicted in Fig. 2.12, the enter menu lists three functions related to data additions and modifications. Each operation is briefly reviewed as follows:

New Building: This option enables the user to create a new project record. After selection, a record appears with all the data fields blank. The user enters the appropriate information in the labeled areas and presses the save button to add the project to the database. The keystrokes, "command N," are an alternative route to this command.

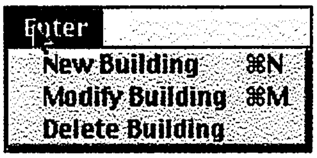


Fig. 2.12 Enter Menu

Modify Building: The selected record can be modified when this tool is implemented. The user may also perform the same task by double-clicking the record of interest or by using the shortcut keys "command M." The modified data can then be entered directly.

Delete Building: The record is permanently removed from the database when this item is selected. One or more records can be deleted at a time.

3 Search Menu

As shown in Fig. 2.13, various pre-defined searches are available to the user at all times. The main eleven search categories correspond to the commonly used project details. For the more uncommon project specifics, customized searches are possible. Primarily all the data fields within a project record can be treated as variables within a customized search. Shortcut keys are provided for many of the queries.

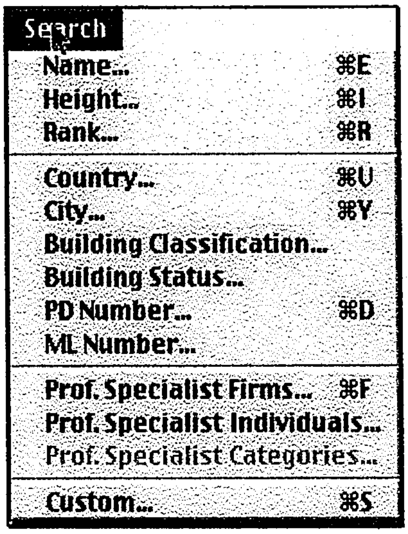


Fig. 2.13 Search Menu

4 Sort Menu

In addition to customized sorts, Fig. 2.14 show the pre-defined sort features that exist within the HRBD. Each option arranges the selected displayed records according to the sort criteria chosen.

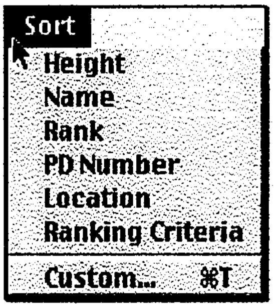


Fig. 2.14 Sort Menu

5 Selection Menu

The Selection menu (Fig. 2.15) provides features associated with two main types of database functions: record selection and multi-list assignments. Each programmed item is briefly described as follows:

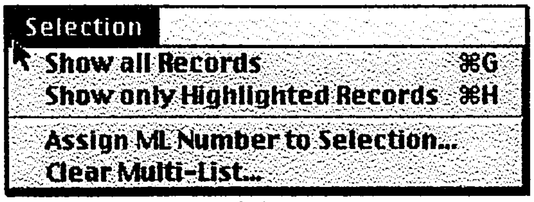


Fig. 2.15 Selection Menu

Show All Records: Restores the display to include all projects documented within the database. By default, the results are sorted by status: built, under construction and under construction - topped out, and then by official height.

Show Only Highlighted Records: By simultaneously pressing the shift and command keys, the user may select one or more records. As the records are selected, they become highlighted. In order to view only these specific records, chose "Show Only Highlighted Records" from the Selection menu. The display is updated to include only the particular projects previously designated. The total number of records within the display is listed at the top center of the project list itself.

Assign ML Number to Selection…: As defined in Section 2.2, the ML number cross references a particular project additional information available in Report 910.14. This function assigns an ML number to all the records within the current display. Each ML number is named and dated. All multi-lists are numerically arranged in the mentioned report.

Clear Multi-List…: This operation removes an ML number from those records with which it is associated. This function is available to ensure that the multi-lists are properly recorded. An ML number cannot be removed from one specific record. Rather, the multi-list must be completely removed from the system and re-entered correctly. Use of this feature is rather uncommon. However, it must be present in order to allow the user flexibility in correcting any inaccurate multi-list assignments.

2.4 UTILIZATION

The HRBD is of use to professional specialists, academia, the media and hobbyists. The facts it provides are used to create Council publications and listings, such as the booklet *The 100 Tallest Buildings in the World* (CTBUH, 1998). The HRBD exposes project ideas and the professional specialists involved, entertains hobbyists and educates students. It is filled with additional contacts and references. In fact, the media persistently consults it for relevant facts and updates.

Studies can be performed by analyzing selected data. For instance, one can determine building trends in a particular country. How many tall steel buildings exist in a certain city? Which architecture firm is highly active in designed tall buildings in a particular country? The HRBD can provide the answers to these questions.

2.5 CURRENT RECORDS PROFILE

A summary of the range of information collected up to the present time in the HRBD is shown in Table 2.10 and Figs.2.16-18. This is presented in order to relay the potential capabilities of the database and the vastness of facts compiled thus far.

Table 2.10 Current HRBD Records Profile Summary

• Total Records	8355
• Total Continents	6
• Total Cities	88
• Total Cities	768

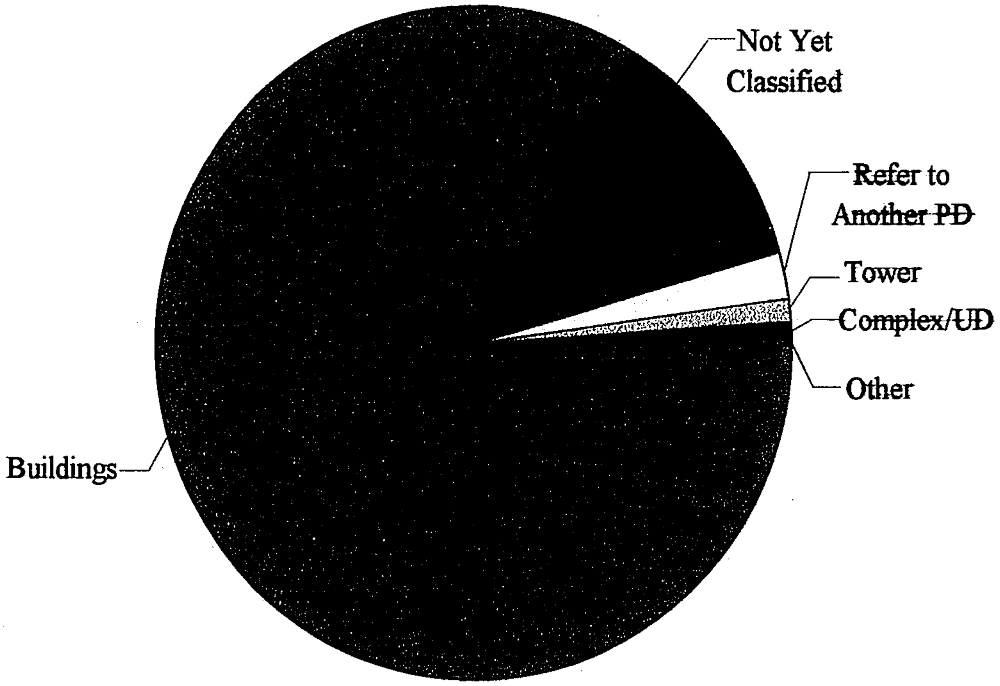


Fig. 2.16 HRBD Project Classes

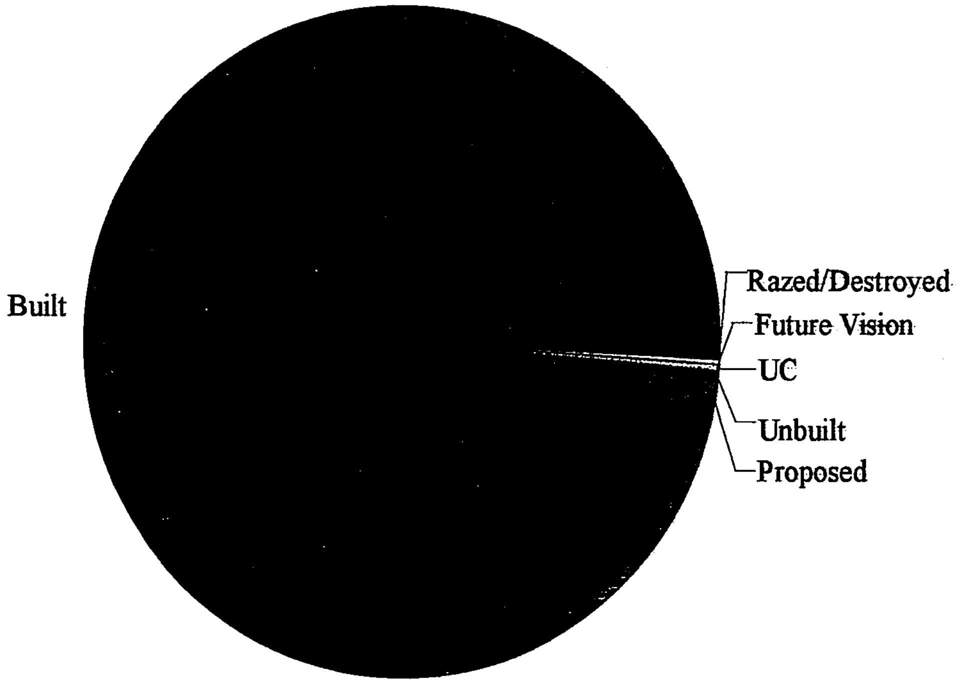


Fig. 2.17 HRBD Project Status

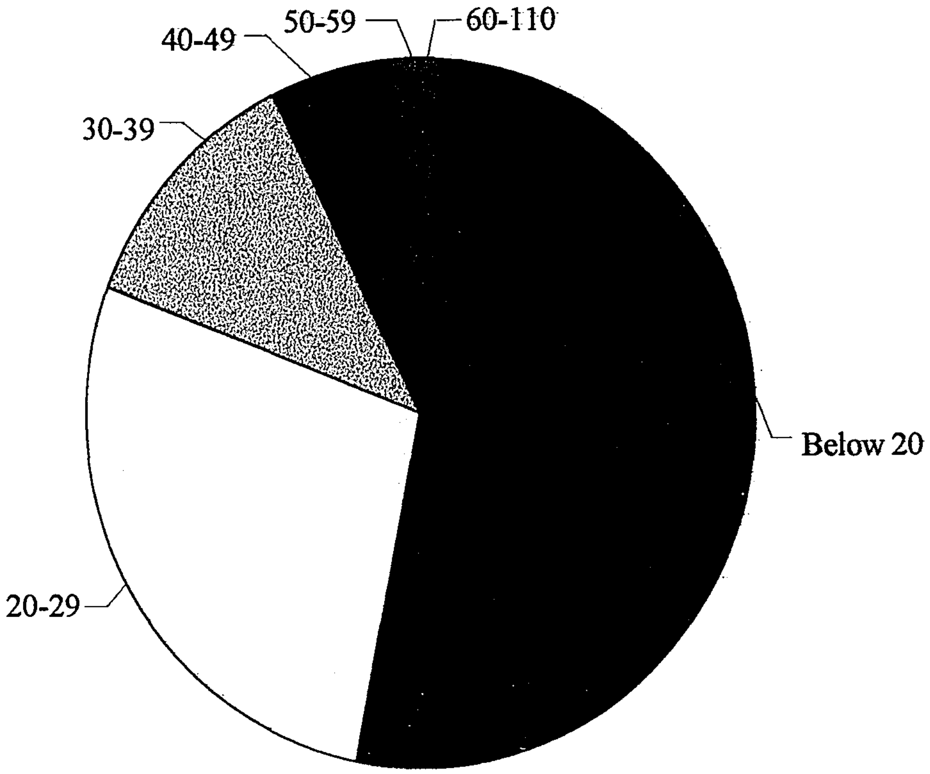


Fig. 2.18 HRBD Built, Proposed and Under Construction Building Stories

2.6 UPDATE STRATEGY

The Council is in the process of updating the database to improve its usefulness to Council members, professional specialists, students, the media, and the general public. Various recent refinements have been made. For instance, entries for height categories, areas and street addresses have been added to the database. Certain building design parameters, listed in Table 2.11, are currently under review by selected Council members for inclusion into the database. All modifications are critiqued by the appropriate committee(s) before the changes are made to the database layout.

The accessibility of the HRBD is increasing. In July of 1997, the Council established its homepage on the internet at *www.lehigh.edu/ctbuh/*. The database can be explored in a read-only mode through this site. Although the format of the on-line database differs from the version found at Council headquarters and discussed in this chapter, the information provided is, more or less, identical (Fig. 2.19). Note that links are provided, when available, to the homepage of the professional specialists involved with a structure. As Fig. 2.20 summarizes, the on-line version of the HRBD is accessed quite often by both members and non-members.

Table 2.11 Proposed HRBD Building Design Parameters

Typical Floor Live Load
Earthquake Load
Seismic Zone
Basic Wind Velocity
Acceleration
Fundamental Period
Damping
Maximum Lateral Deflection
Aspect Ratio

High Rise Buildings Database

AT&T Corporate Center

City: **Chicago**	Material: **Mixed**
Country: **USA**	Use: **Office**
Number of Stories: **60**	Classification: **Building**
Rank: **20**	Status: **Built**
Year of Completion: **1989**	Council PD Number: **1587**

Height Information

	Structural Top	Highest Occ. Fl.	Top of Roof	Top of Tower/Mast
Meters	307	252	270	307
Feet	1007	826	885	1007

Professional Specialists

Architect	Skidmore, Owings & Merrill
Structural Engineer	Skidmore, Owings & Merrill
Developer	Stein & Co.
Services Engineer	Skidmore, Owings & Merrill
Construction Manager	Oppenheim, Mike Assoc.

Fig. 2.19 HRBD: Internet Version

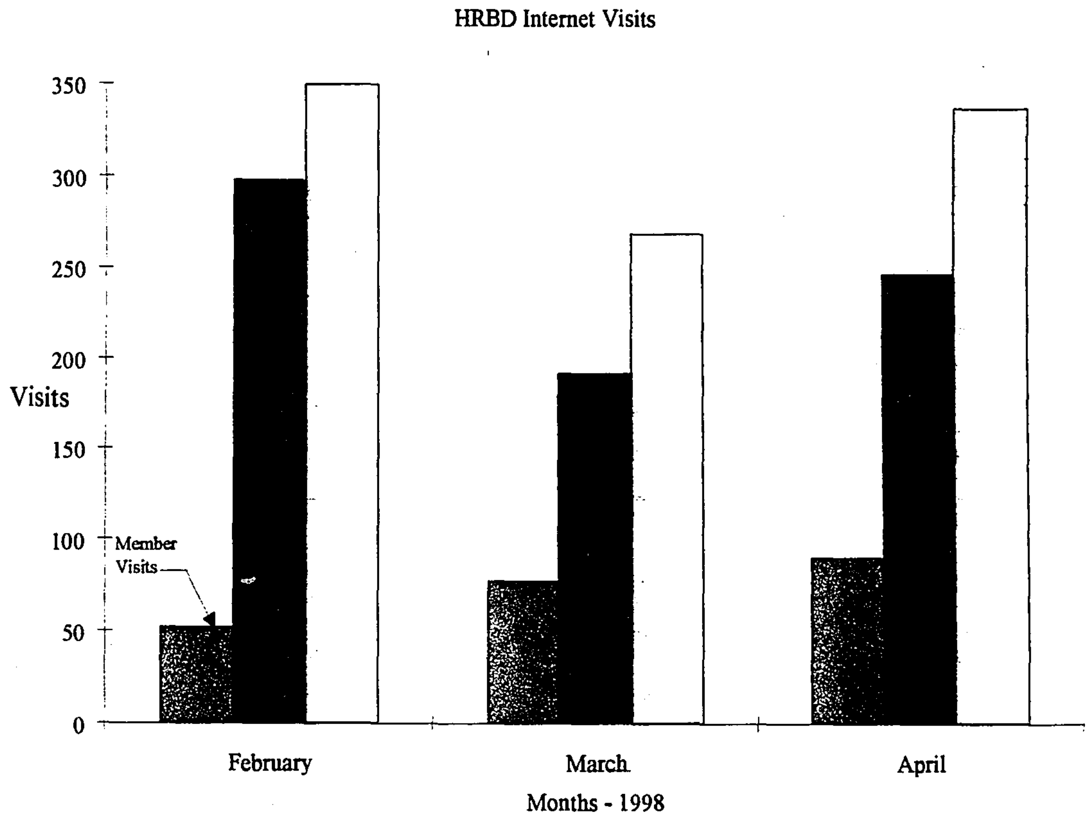


Fig. 2.20 HRBD Internet Visits (Feb98-Apr98)

3. TALL BUILDING SYSTEMS

In the preliminary stages of this project, the type, or types, of tall building systems to be classified were selected. Prior to any decision, the tall building systems hierarchy was briefly reviewed from the perspective of a graduate research assistant with a structural engineering and architectural background.

Although many arrangements are possible, it seemed appropriate to start with the four main tall building systems previously identified by the Council (1976). The categories so identified are Loading, Functional, Physical, and Building Implementation. Each is concisely listed as follows, along with the corresponding subsystems.

Another arrangement is presented by the Council in its eight Topical Groups. Within each group are specialty committees appropriate to the topic. All four systems, Loading, Functional, Physical and Building Implementation, are incorporated with the work of each Topical Group and Topical Committee (CTBUH Brochure, 1998). Table 3.1 lists this alternative arrangement.

This thesis deals with structural framework, which is a subcategory of Physical Systems. Eventually, it would be hoped that similar classifications could be prepared for the other systems as well.

3.1 LOADING SYSTEMS

The major types of loads applied to tall buildings are grouped within the main category of Loading Systems. The HRBD update effort recognizes most of the subsystems listed in Table 3.2. As mentioned in Section 2.6, certain building design parameters are currently under review for inclusion into the database. The typical live load, at both the service and ultimate levels, the earthquake load and the typical wind velocity are all included in the proposal.

3.2 FUNCTIONAL SYSTEMS

Table 3.3 lists the items included within Functional Systems. The subsystems primarily relate to the use of the building, its operation, and its impact upon the environment. For example, utilization, or building use, is a an item within the Functional Systems. As mentioned in Chapter 2.2, Table 2.3A expands this particular component. Together with the Loading Systems, they are the rationale behind the physical systems of a building.

3.3 PHYSICAL SYSTEMS

The tangible items which represent the actual building and its components are the Physical Systems. Table 3.4 summarizes the system's subdivisions. Note that structural framework is one of the sub-categories. This particular system seemed the most suitable to scrutinize due to the research assistant's background.

3.4 BUILDING IMPLEMENTATION SYSTEMS

The complete life-cycle of a building is reflected by the Building Implementation Systems shown in Table 3.5. They start with the need for tall buildings, continue with the philosophy of tall buildings, and end with the demolition of tall buildings.

4. STRUCTURAL SYSTEMS

4.1 NEED FOR A CLASSIFICATION SYSTEM

The demand for an accepted tall buildings structural systems classification stems from the need for a proper and consistent reference to the many systems and subsystems possible. With such a scheme established, more direct, clear comparisons are possible. Most importantly, the scheme can be implemented into the Council's HRBD.

By enhancing the HRBD with the structural systems classification, more correlations are instantly available. For instance, one may study the types of buildings within the eighty to ninety story range that are compromised of a framed tube. The eighty story Amoco building, located in Chicago, is a prime example of such a system (Fig 4.1). The many types of structures with such a system can be retrieved from the HRBD using the appropriate query. Other trends in design parameters, such as wind velocity, aspect ratio, or drift, can then be explored by exporting the data from the database.

Over time, an assessment of performance characteristics can be recorded. The structural systems classifications and the HRBD can even be used as a general reference point in providing a comfort level for clients interested in similar projects. Likewise, professional specialists may consult this aspect of the HRBD for structural system examples to stimulate ideas or to provide a point of departure in the design stage.

Such a classification may also be applied to computer networks in inventive problem solving in engineering. The systems could be studied to lead to new types of structures and systems (Arciszewski, 1986). In fact, a similar type of study, focusing only upon wind bracing classification, is being investigated by Arciszewski (1998).

Initially, the structural systems classification suggested may be a simplified one. The scheme must be simple enough so that it can be effectively used within the HRBD and the tall building survey form. Such an undertaking must be completed in stages. The initially simple classification facilitates the collection of data as well as the database programming involved. However, as the HRBD is maintained with this new type of information, the classification scheme may be modified accordingly in cooperation with Council Committee 3. The modifications can include new subsystems and even new general categories, if ones are engineered.

Consequently, Committee 3 is in the early stages of planning a second edition of the Council's Monograph on Structural Systems. Should the classification system suggested in this thesis be adopted by Committee 3, it could provide the basis, or reference guide, for the new release. For instance, the second edition's chapters could be arranged to coincide with the classification. The HRBD could even be referenced for specific examples of each type of system to be included with the book.

4.2 FACTORS AFFECTING CHOICE OF STRUCTURAL SYSTEMS

A sophisticated structural systems classification may assist the professional specialists in actually selecting a certain framework. Although the scope of the current classification may not effectively aid in the selection of tall buildings systems, it should not be entirely dismissed. Studies which relate each system to other selection factors are required in order to have such an efficient structural system reference guide. Table 4.1 puts this task in perspective by listing just some of the major factors influencing the choices of structural systems.

For example, different types of materials, concrete, steel, or composite, are considered when selecting a structural system. The location of the proposed structure contains numerous influential design factors such as seismic zone, soil conditions, or typical wind velocity. The economy and sometimes even the architecture also impact the selection of structural systems. These issues are just a few of the main items addressed in Table 4.1.

4.3 APPROACH TO DEVELOPMENT OF CLASSIFICATION

The classification scheme is initially intended to include tall buildings built, under construction or seriously proposed. It is not yet developed to include the future vision projects. Projects of this nature include Frank Lloyd Wright's Mile High Tower (Fig 4.2), Aeropolis (Fig. 4.3), Takenka's Sky City 1000 (Fig 4.4), or the Tokyo Millennium Tower (Fig. 4.5). Other examples of these types of projects are listed in Table 4.2.

As seen in Fig. 2.18, over 75% of the buildings consist of less than thirty stories. Over half of the buildings built, under construction, or proposed in the HRBD are below twenty stories. In order to produce an effective classification system, the scope of buildings considered must be initially streamlined. Therefore, this study considers only the tallest portions of buildings built, under construction or proposed. Namely, it focuses on those buildings satisfying the mentioned criteria that are above ten stories. A similar study may be performed to integrate the lower story buildings.

Once the intended scope of the classification system was set, the next step was to review the literature. Starting with the primary classifications, materials reviewed included engineering textbooks, the Council's monographs, proceedings and the Council's project description files. An e-mail discussion forum was setup with members of Committee 3 and other selected professional specialists. This means of correspondence provided important suggestions, contacts and further references.

With all these resources in mind, the following approach was used to generate a consistent and effective classification of the primary lateral and gravity load resisting systems.

(1) Formulate a list of all lateral and gravity load resisting systems mentioned in all sources;

(2) Study the geometric characteristics of the lateral and gravity load resisting systems;

(3) Develop a general classification;

(4) Generate a discussion with members of the Council's Structural Systems Committee 3 via an e-mail discussion forum;

(5) Modify the scheme accordingly;

(6) Test the classification by applying it to numerous projects within the HRBD.

5. LITERATURE REVIEW

5.1 PREVIOUS CLASSIFICATION SCHEMES

The examination of previous classification systems provided a fundamental starting point for this research project. In performing this portion of the study, it was apparent that there are various approaches in successfully categorizing the systems. Fortunately, this was discovered early in the study, making aware the many methods in addressing the problem. By studying the past works of others and knowing the attempts others had made, it was possible to foresee the method most suitable in achieving the research objectives.

1 Falconer and Beedle

Falconer and Beedle (1984) developed a scheme which encompasses four main tall building systems: structural systems, structural materials, mechanical systems, and architectural systems. These main categories were expanded into more detailed divisions as shown in Table 5.1. The structural systems were further subdivided into classifications of bracing subsystems and floor framing (Tables 5.2 and 5.3). (These two categories are not included in this study.) Tables 5.4-6 provide a detailed summary of the structural materials, the mechanical systems, and a portion of the architectural systems classification. These latter were also not dealt with herein, since the objective is to develop a definitive classification of the vertical and horizontal load carrying systems.

2 Structural Systems Monograph

Although Committee 3 of the CTBUH has yet to formally adopt a structural systems classification, the monograph chapter sequence indeed reflects some sort of organization. This arrangement is included in Table 5.7.

3 Khan

The classification scheme suggested by Khan (1973) takes into account the building material (concrete and steel) as shown in Fig 5.1. Within each scheme, he identifies the structural systems most commonly used for each material as follows:

Concrete	Steel
Frame	Rigid Frame
Shear Wall	Frame-Shear Truss
Frame-Shear Wall	Belt Truss
Framed Tube	Framed Tube
Tube-in-Tube	Truss-Tube with Interior Columns
Modular Tube	Bundled Tube
	Trussed Tube without Interior Columns

It is interesting that "composite" is not included. In 1973, the development of composite systems was yet to come. Ironically, Khan was the initiator of the development of composite systems.

4 Taranath

Another approach to classifying structural systems was performed by Taranath (1988). His categorization incorporates the material type as well as the loading type as shown in Table 5.8. This arrangement is well suited for the chapter arrangement of tall building structural analysis textbooks.

5 Smith and Coull

Table 5.9 summarizes yet another arrangement developed by Smith and Coull (1991). The structural form (structural framing) is the basis for their suggested scheme. This classification is also used as a chapter guideline within the referenced textbook.

5.2 LITERATURE OF STRUCTURAL SYSTEMS

As mentioned, the need for a proper and consistent reference to tall building structural systems stimulated this study. In fact, there is a significant lack of a consistent terminology for the various structural systems utilized throughout the engineering industry. Often a certain term is used to describe one type of system by one engineer, but another engineer used that same term to describe a different type of system. Table 5.10 lists terms encountered in the literature. The variety is so great that there is no wonder there is confusion and inconsistency. This confusion was dealt with by inspecting this list and determining the most common terms used.

5.3 PROJECT DESCRIPTION FILES

The Council's project description files (designated PD) contain a large amount of technical detail. A record was assembled of the terminology used for selected buildings (Table 5.11). This, too, is used to exemplify the lack of a consistent vocabulary and to conclude which structural systems were the most common. These observations provided the basis for the classification system suggested as a result of this research.

5.4 INTERVIEWS AND CONVERSATIONS

In developing the classification scheme, the writer often collaborated with professional specialists in industry and academia. These conversations were the most influential factors in deciding to base the classification on geometry. Both Beedle and Elnimeiri agreed that the classification should be based upon this aspect. Elnimeiri stated that the classification "should be based upon geometry." Although the writer felt that a geometrical basis would be appropriate, other ideas were expressed. Faschan reasoned "...you have steel systems, concrete systems, composite system." The individuals mentioned in the selected references were also very helpful in referring the writer to additional literature.

5.5 STRUCTURAL SYSTEMS E-MAIL FORUM

A structural systems e-mail forum (STRSYS-L) was established in order for rapid communication between selected members of the Council, Committee 3, and between themselves as well. This discussion forum also included individuals listed in selected references. Developing classification schemes or questions were posted, resulting in significant feedback. This valuable tool enabled the researcher to receive many different points of view.

More specifically, the response received from STRSYS-L influenced many decisions throughout this study. For example, it provided excellent points about the basis of the classification. As Sinn of Skidmore, Owenings and Merrill (Chicago) suggested in his 04Feb98 e-mail: "...any system categorization would have to begin by listing by deformation characteristic(s)..." Although this classification approach was not utilized in the current study due to its complexity, it was important to take that method into consideration in the beginning of the study. Additional suggestions were posted about other issues as well. For instance, on 28Mar98, Kowalczyk addressed the level of detail issue by noting that "…the system should be as simple as possible…" This point of view was shared with all the subscribers of STRSYS-L. Hence, throughout the research, a major goal was to keep the classification as straight-forward as possible. Utilizing STRSYS-L as a viable means of communication proved to be worthwhile since it reinforced many decisions made throughout the study.

6. DISCUSSION AND EVALUATION

The engineering profession at large generally agrees that a study should be conducted on the classification of structural systems. However, not all are in agreement with how. Although there were several indirect attempts to establish a classification (Taranath, 1988, Smith and Coull, 1991), there is only one study on the actual topic (Falconer and Beedle, 1984).

As Chapter five reveals, the literature is full of inconsistent terminology. For example, Moore and Gosain (1986) use the term "exterior tube" to describe the same system Iyengar calls a "perimeter framed tube." Iyengar also uses another term, "perimeter framed tube," in discussing the same system. This lack of standard terms requires the establishment of a glossary and classification system in order to resolve the confusion.

6.1 CLASSIFICATION PROBLEMS

Prior to the development of a structural systems classification, some critical factors need to be addressed. First, the basis of the classification needs to determined. For instance, it may be based upon materials, deformation or behavior, analysis methods or even geometry. The appropriate level of detail required must also be identified. For instance, how many sub-categories should be developed? One must keep in mind that the scheme be simple enough so that it can be implemented within the HRBD and the tall building survey form (Table 6.1). A classification scheme which is too complicated may otherwise render its application useless.

As mentioned, it is evident that the actual use of a standard structural systems vocabulary is not found in the literature. Often, the same terms are used by different individuals to describe different systems. Thus, clear demarcations between systems of actual buildings must be established. Consider the term "megastructure." Leslie Robertson uses this term to describe the Bank of China in Hong Kong (Fig 6.1). On the other hand, the proposed Shimuzu Super High-Rise (Fig. 6.2) is also defined as a "megastructure" in the *Structural Systems Monograph* (CTBUH, 1995). Yet, the two systems are not identical. (Coincidentally, the *Structural Systems Monograph* considers the Bank of China a trussed tube.)

Other issues also complicate this matter. For example, the first tubular buildings were termed "framed tube" due to the fact that the system was derived as a logical extension of the frame system. That is, the beam and column members were enlarged and the columns closely spaced to mimic a punched tube. Therefore, in a sense, some tubular buildings may be considered frames.

A similar situation exists for shear walls. One must distinguish between isolated shear walls and those which resemble a closed polygon, or core, in plan. To add further difficulty, many building systems are hybrids or combinations of more than one system. As a result of this study, it is estimated that approximately one-half of all tall buildings are compromised of more than one system. In other words, they are hybrids. Should an attempt be made to identify each different hybrid arrangement? How exactly should hybrid systems be handled?

6.2 RESOLUTION OF CLASSIFICATION PROBLEMS

The classification basis is the issue that needs to be addressed first. By reviewing the terminology encountered during this research (Chapter Five) it was decided to base the classification primarily upon geometry. Most of the structural system descriptions refer to the geometric configuration of the system. Very few definitions rest on load-resisting functions (one example is “moment resisting frame”). It is clear that the geometric arrangement of a building’s systems provides the best physical description of the actual structure.

The number of these main categories was to kept to a minimum. In fact, the writer initially strived to create a classification which avoided the category of combinations (hybrid systems). However, as stated, it is estimated that over one-half of all tall buildings are combinations of two or more systems. This make it inevitable that such a category must exist.

It was thought to generate only one level of subcategories within each major system. This seemed appropriate for initializing the scheme into the HRBD and incorporating it into the tall building survey form.

In order to provide clear demarcations between systems, concise definitions of each category must be provided. This includes both a written description and graphical representation of the typical geometric properties of the categories. These definitions will be included on the survey form and in the HRBD (Chapter Seven).

In order to avoid the majority of buildings being classified as some type of hybrid system, it must be attempted to group a building within one of the “primary” systems. It was decided that if 50% or more of the total load is carried by a given system, it would be designated in that category. Otherwise, the structure would be considered a combination or hybrid system. It seems logical that the subsections of the hybrid systems category is compromised of any combination of the other primary systems' categories or sub-categories identified.

7. SUGGESTED CLASSIFICATION SYSTEM

7.1 PRIMARY SYSTEMS

The five major systems: cores, frames, tubes, walls and combinations (hybrid systems) - were selected by using the methods earlier described. The four suggested primary systems are: cores, frames, tubes and walls. Each is clarified as follows:

Cores: The main load resisting system is concentrated around the elevator or service core(s). This category includes, but is not limited to, cores made up of shear walls. A core that is framed is also included in this group.

Frames: Assemblage of beams and columns that resist the load either as a braced frame (shear truss) or a moment resisting frame. Relatively speaking, the columns are widely spaced and the girder depths are essentially those needed to support the vertical load.

Tubes: Assemblage of beams and columns in which the members are situated on the perimeter of the building. In framed tubes, the columns are closely spaced and the girder depths are usually greater than those for the usual frame system. In trussed tubes, the diagonal members carry the major lateral forces. Thus, very closely spaced columns are not often seen. Bundled tubes are made up of numerous tubular structures assembled next to each other for increased strength. The column spacing for this type of spacing is relatively wide.

Walls: Systems consisting mainly of isolated walls including shear walls, gravity load bearing walls, and infilled panels. It does not include systems made of these components that are situated around a central core.

These four primary categories are actually derivatives of two main systems, shear walls and frames. However, a more specific level of detail is required in order to accurately describe the more common tall building structural systems. For example, Toronto City Hall (Fig 7.1) contains an exterior shear wall arrangement. This is very different from the concentrated (clustered) shear wall generally found around the elevator or service core(s). Both systems do contain shear walls, but in very different arrangements. This observation forced the generation of categories which refer to each type of system, cores and walls.

Similarly, the tube is a derivation of the typical frame. Relatively speaking, however, the tube consists of closely spaced columns and deep spandrels. Hence, each type of system has its own primary category.

7.2 SUBSYSTEMS

The corresponding subsystems are identified in Table 7.1. The subcategories selected are those most commonly found in literature - more or less a consensus of professional opinion. Note that it would seem appropriate that the subset of combinations (hybrid systems) consists of any mixture of all the other primary systems' subcategories.

7.3 OTHER POSSIBLE STRUCTURAL ELEMENTS INVOLVED

Other possible structural elements involved within each system or subsystem are also as follows: bracing, outriggers, belt trusses, hat trusses and slitted shear walls. Again, the classification is kept simple by opting not to integrate these additional elements within the sub-categories. If one or more of these elements are present in a building's system, then the term may be separately added to the description of the overall system within the HRBD.

7.4 CLASSIFICATION OF SELECTED BUILDINGS

Examples of some of the primary systems and some that illustrate the subsystems are provided. In Figs. 7.1 through 7.8 are shown some examples of the different core systems. Braced and moment resisting frames, are illustrated in Figs. 7.9-11. Tube systems are shown in Figs. 7.12-14. An example of an exterior shear wall system, a wall sub-category, is included in Fig 7.1.

The Mitsui Building is evidently a hybrid. However, over 50% of the total load is carried by the moment resisting frame. It would be listed, then, under "frames." (The slitted shear walls take 20% of the total load while the diagonal bracing resists 30%.)

8. IMPLEMENTATION INTO THE HIGH-RISE BUILDING DATABASE

8.1 HIGH-RISE BUILDING DATABASE FORMAT

Figure 8.1 shows a database building record in which the structural system tab has been selected. The triangular diagram, shown on the left portion of the database record, adapted from Drosdov and Lishak (1978), is designed to facilitate the input of the structural system. Note that the larger, black circles within the diagram indicate the four primary systems: core, frames, tubes, and walls. The smaller, white circles refer to the more common combination (hybrid) systems.

To input the correct structural system for a building, double-click the appropriate primary system from the triangular diagram (in this case "tube"). A selection box then appears to the right of the triangular diagram as shown in Fig 8.2. This new selection box lists the corresponding sub-categories available. Highlighting each sub-category reveals a diagram of the typical plan and elevation associated with that particular system. Once the appropriate sub-category is recorded, double-clicking adds it to the building record. Listed in the lower portion of the structural systems screen are the primary system and subsystem selected.

Similarly, combination systems are hybrids of the other four systems. In order to indicate a combination system, select the desired smaller, white circles from the triangular diagram. Once a combination is selected, say cores and frames, then all sub-categories associated with each of these systems is listed in the middle selection box. Now, the correct combination system can be indicated by selecting the sub-categories which best describe the actual system.

Additional parameters have also been included to provide more detailed descriptions of a building's structural system. Check boxes (lower left hand corner of structural system screen) are available for instances where other possible structural elements are involved. Furthermore, the search and sort functions can also include items with respect to structural systems and design parameters. Therefore, the data may be manipulated with respect to these items.

8.2 MODIFIED SURVEY FORM

One purpose of this study was to provide a suitable format for adding "structural system" to the other important items in the Council's HRBD. Up to the present time, the Council's survey form has had to exclude requests for information on structural systems (Table 6.1) because there was no agreement on what terms to use.

Table 8.1 shows a suggested new survey form. Each category is concisely explained on the back of the form, as are classification guidelines. It is hoped that this modified form would simplify the completion of future surveys. This results in a more detailed description of buildings, thus enhancing the value of the database.

8.3 EXPANSION OF THE HIGH-RISE BUILDING DATABASE

In addition to the implementation of a structural systems classification scheme, various design parameters should be included in the type of information solicited by the Council. Figure 8.3 indicates one such expansion and its layout within a typical building record. It covers floor loads, earthquake and wind parameters, stiffness parameters, fundamental period, and slenderness ratio.

9. SUMMARY

A description of the Council's HRBD is given, noting the significant value of this remarkable resource. Through literature review and interacting with members of academia and industry, a tall building structural systems classification has been suggested. Its essence is four primary systems: cores, frames, tubes, and walls together with combination (hybrid) systems (those for which no one primary systems is dominant). The most appropriate and commonly used subsystems are identified.

Though many problems arose, such as the required level of detail or overlap between categories, the scheme provides a framework to describe structural systems for tall buildings. It is simple enough to be applied to the HRBD and the tall building survey form. Yet, it is detailed enough to enable a distinction to be made between different types of major systems.

With the addition of the structural systems and the design parameters, there are new opportunities afforded by the HRBD. Comparative structural system studies may be conducted covering such factors as sensitivity to seismic and extreme wind distress. This type of information would eventually provide the basis for actual building performance comparisons. This would be of particular value to professional specialists during the preliminary design stages.

As the Council's committee on structural systems (#3) is preparing the second edition of its monograph (CTBUH, 1995), it is hoped that this classification may facilitate adaptation of standard terms to describe the structural systems of tall buildings. This reduces the confusion that now appears in the literature.

369-14
~~20Mar76~~
01Apr76

Schedule 14.6

Tabel 2.1 Original Council Tall BuildingSurvey Form

JOINT COMMITTEE ON TALL BUILDINGS

Fritz Engineering Laboratory #13, Lehigh University
Bethlehem, PA 18015 USA

BUILDING HEIGHTS AND OTHER CHARACTERISTICS Country: ____________

Reply Form

Please list the ten TALLEST buildings and also other INTERESTING, UNIQUE, or HISTORICAL Tall Buildings in YOUR CITY. (Follow key on reverse side of this form.) Please return as soon as possible, but no later than June 1, 1976.

City	Building Name	(1) Number Stories	Height Ft	Height M.	Year Comp-leted	(2) Material	(3) Use	(4) Structural System	(5) Notes	(6) Enc. Slides
SAMPLE: Anytown, USA	Merchant's Bank	14/3	149	46	1967	Concrete	Office	Rigid frame (beam to column) Precast panel floor	Tallest in city	X

NUMBER OF BUILDINGS IN HEIGHT CATEGORIES: To determine the statictical distribution of numbers of buildings grouped according to number of stories in various categories, we also need the following information:

Number of buildings: 9-19 stories ________ 40-59 stroies ________
20-39 stories ________ 60 stories and over ____

DATE ____________ NAME ____________ ADDRESS ____________

Tabel 2.1(continued) Original Council Tall BuildingSurvey Form

KEY

(1) Stories both above and below ground level: (Stories above ground / stories below ground).

(2) Steel, concrete, mixed, masonry, timber, etc. Also note where there are variations with height.

(3) Apartment, office, hotel, manufacturing, warehouse, hospital, multiple use, etc.

(4) Please give as detailed a description as you can. The following has been provided to help you choose appropriate definitions. However, you need not be restricted by the list since you may provide as much pertinent information as you deem necessary -- frame, rigid frame (beam to column), braced frame, staggered frane system, frame with load bearing walls, frame with central core, frame with shear walls, core with cantilevered floors, core with suspended floors, tube, framed tube, braced tube, exterior framed tube, cast in place panel floors, precast shear walls, precast load bearing walls, etc.

(5) Historic "firsts" and other items of interest. (Show in Notes)

(6) Check in column if additional information and/or photogrpahs are enclosed.

Table 2.2 Typical Council Professional Specialists Survey Form

903-310
22Oct97

PROFESSIONAL SPECIALISTS

Schedule 14.22b

Building Name	**City**
______________	______________

For Office Use Only:

PD: __________

Date: __________

Architect(s)	__________	__________
	__________	__________
Developer(s)	__________	__________
	__________	__________
General Contractor(s)	__________	__________
	__________	__________
Mech./Services Engineer(s)	__________	__________
	__________	__________
Owner(s)	__________	__________
	__________	__________
Structural Engineer(s)	__________	__________
	__________	__________
Other(s), please specify	__________	__________
	__________	__________

Respondent's Name and Address: __________

Phone, Fax, Email numbers: __________

Table 2.3: HRBD Represented Countries and Cities

Country	City	Country	City
Argentina	Buenos Aries	Bulgaria	Botrvgrad
Argentina	Cordoba	Bulgaria	Bourgas
Australia	Adelaide	Bulgaria	Gabrovo
Australia	Astoria	Bulgaria	Jambol
Australia	Brisbane	Bulgaria	Kardjali
Australia	Canberra	Bulgaria	Kjustendil
Australia	Coral Sea	Bulgaria	Lovech
Australia	Geelong	Bulgaria	Mihajlovgrad
Australia	Hobart	Bulgaria	Pazardjik
Australia	Melbourne	Bulgaria	Pernik
Australia	North Sydney	Bulgaria	Pleven
Australia	Perth	Bulgaria	Plovdiv
Australia	Queensland	Bulgaria	Razgrad
Australia	Surfers Paradise	Bulgaria	Rousse
Australia	Sydney	Bulgaria	Samokov
Austria	Linz	Bulgaria	Sliven
Austria	Vienna	Bulgaria	Sofia
Austria	Wels	Bulgaria	Stara Zagora
Austria	Zeltweg	Bulgaria	Svishtovy
Azerbaijan	Baku	Bulgaria	Varna
Bahrain	Manama	Bulgaria	Veliko Tirnovo
Bangladesh	Chittagong	Bulgaria	Vidin
Bangladesh	Dhaka	Bulgaria	Vratsa
Barbados	Bridgetown	Canada	Calgary
Belarus	Minsk	Canada	Edmonton
Belgium	Anvers	Canada	Guelph
Belgium	Brussels	Canada	Halifax
Belgium	Charleroi	Canada	Hamilton
Belgium	Ghent	Canada	London
Belgium	Liege	Canada	Montreal
Belgium	Louvain	Canada	Niagara Falls
Belgium	Marcinelle	Canada	Ontario
Belgium	Mons	Canada	Ottawa
Belgium	Ostend	Canada	Quebec
Botswana	Gaborone	Canada	Regina
Brazil	Belem	Canada	Richmond
Brazil	Belo Horizonte	Canada	Toronto
Brazil	Brasilia	Canada	Vancouver
Brazil	Campinas	Canada	Winnipeg
Brazil	Caxias Do Sul	Chile	Osorno
Brazil	Macau	Chile	Rancagua
Brazil	Niteroi	Chile	Santiago
Brazil	Porto Alegre	Chile	Santiago
Brazil	Rio de Janeiro	Chile	Vina del Mar
Brazil	Salvador	China	Anhui Province
Brazil	Santos	China	Beijing
Brazil	Sao Paulo	China	Changchun
Bulgaria	Blagoevgrad	China	Chongqing

Table 2.3 (continued): HRBD Represented Countries and Cities

Country	City	Country	City
China	Dalian	Egypt	Asswan
China	Forshan	Egypt	Cairo
China	Fuzhou	Egypt	Giza
China	Guangzhou	Egypt	Heliopolis
China	Guilin	Egypt	Nasr City
China	Haikou	Egypt	Sadat City
China	Hainan Island	England	Beaconsfield
China	Hefei	England	Birmingham
China	Kunming	England	Blackpool
China	Lanzhou	England	Cambridge
China	Nanchang	England	Cheshire
China	Nanjing	England	Coventry
China	Nanning	England	Derby
China	Nunhai	England	Essex
China	Peking	England	Gateshead
China	Qingdao	England	Gwent
China	Shanghai	England	Hatfield
China	Shekou	England	Huddersfield
China	Shenyang	England	Hull
China	Shenyang	England	Lanarkshire
China	Shenzhen	England	Leeds
China	Taiyuan	England	Leicestershire
China	Taiyun	England	Liverpool
China	Tianjin	England	London
China	Wuhan	England	Manchester
China	Xiamen	England	Middlesbrough
China	Xian	England	Milton Keynes
China	Zhengzhou	England	Nottingham
China	Zhuhai	England	Portsmouth
Colombia	Bogota	England	Preston
Colombia	Cali	England	Salford
Colombia	Medellin	England	Scunthorpe
Croatia	Zagreb	England	Surbiton
Czech Republic	Bratislava	nEngland	Walsall
Czech Republic	Brno	England	Wrexham
Czech Republic	Gottwaldov	Estonia	Tallinn
Czech Republic	Liberec	Finland	Espoo
Czech Republic	Most	Finland	Helsinki
Czech Republic	Ostrava	Finland	Tampere
Czech Republic	Prague	France	Bordeaux
Denmark	Aalborg	France	Boulogne
Denmark	Arhus	France	Evry
Denmark	Copenhagen	France	Lille
Denmark	Esbjerg	France	Lyon
Denmark	Haderslev	France	Marseilles
Denmark	Sitkeborg	France	Nantes
Ecuador	Guayaquil	France	Nice
Ecuador	Quito	France	Noisy Le Grand
Ecuador	Salinas	France	Paris

Table 2.3 (continued): HRBD Represented Countries and Cities

Country	City	Country	City
France	Rennes	Iran	Teheran
Germany	Berlin	Iran	Tehran
Germany	Bonn	Iraq	Babylon
Germany	Braunschweig	Ireland	Dublin
Germany	Dresden	Israel	Haifa
Germany	Dusseldorf	Israel	Jerusalem
Germany	Essen	Israel	Negev Desert
Germany	Frankfurt	Israel	Ramat-Gan
Germany	Halle	Israel	Tel Aviv
Germany	Hamburg	Italy	Brescia
Germany	Hannover	Italy	Chiavari
Germany	Jena	Italy	Florence
Germany	Karl Marx Stadt	Italy	Genoa
Germany	Karlsruhe	Italy	Lecco
Germany	Koblenz	Italy	Milan
Germany	Koln	Italy	Naples
Germany	Leipzig	Italy	Palermo
Germany	Leverkusen	Italy	Pisa
Germany	Ludwigshafen	Italy	Rome
Germany	Magdeburg	Italy	Salice D'Ulzio
Germany	Munich	Italy	San Girug Rano
Germany	Rostock	Italy	Sestriele
Germany	Ulm	Italy	Torino
Ghana	Accra	Italy	Turin
Greece	Athens	Italy	Valencia
Greece	Rhodes Island	Italy	Venice
Hong Kong	Causeway Bay	Japan	Asahigawa
Hong Kong	Hong Kong	Japan	Ashiya
Hungary	Budapest	Japan	Chiba City
India	Agra	Japan	Chuo
India	Ahmedabad	Japan	Fukui
India	Bangalore	Japan	Fukuoka
India	Bihar	Japan	Hachiouji
India	Bombay	Japan	Hamamatsu
India	Calcutta	Japan	Hiroshima
India	Cochin	Japan	Kagoshima
India	Delhi	Japan	Kanazawa
India	Hyderabad	Japan	Kawaguchi
India	Indore	Japan	Kawasaki
India	Lucknow	Japan	Kita-Kyushu
India	Madras	Japan	Kobe
India	Mumbai	Japan	Konoike
India	New Bombay	Japan	Kumamoto
India	New Delhi	Japan	Kyoto
India	Panigoa	Japan	Maebashi
India	Pondicherry	Japan	Makuhari
India	Trivandrum	Japan	Matsudo
Indonesia	Jakarata	Japan	Matsumoto
Indonesia	Kuala Lumpur	Japan	Nagoya

Table 2.3 (continued): HRBD Represented Countries and Cities

Country	City	Country	City
Japan	Naha	Malaysia	Sandakan
Japan	Narashino	Malaysia	Subang Jaya
Japan	Niigata	Malaysia	Ulu Kelang
Japan	Nishinomiya	Mali	Bamako
Japan	Ohgaki	Mexico	Acapulco
Japan	Okayama	Mexico	Mexico City
Japan	Osaka	Mexico	Monterrey
Japan	Pusan	Moldova	Kishinev
Japan	Saitama	Monaco	Monaco
Japan	Sapporo	Moon	Moon
Japan	Sendai	Morocco	Casablanca
Japan	Shanghai	Netherlands	Amsterdam
Japan	Shinjuku	Netherlands	Amstelveen
Japan	Shizuoka	Netherlands	Arnhem
Japan	Sizuoka	Netherlands	Delft
Japan	Suita	Netherlands	Enschede
Japan	Taisei	Netherlands	Rotterdam
Japan	Takamatsu	Netherlands	Ryswyk
Japan	Toba	Netherlands	Schiedam
Japan	Tokyo	Netherlands	The Hague
Japan	Toyoaki	Netherlands	Utrecht
Japan	Wakayama	Netherlands	Voorburg
Japan	Yamagata	Netherlands	Zandvoort
Japan	Yamaguchi	Panama	Panama City
Japan	Yokohama	Papua N. Guinea	Lae
Japan	Yono	Papua N. Guinea	Port Moresby
Kenya	Mombasa	Peru	Lima
Kenya	Nairobi	Philippines	Makati
Korea	Kwangju	Philippines	Manila
Korea	Pusan	Philippines	Pasay City
Korea	Pyongyang	Philippines	Pasig
Korea	Seoul	Philippines	Quezon City
Kuwait	Kuwait City	Poland	Bydgoszcz
Latvia	Riga	Poland	Gdansk
Lebanon	Beirut	Poland	Katowice
Luxembourg	Luxembourg	Poland	Krakow
Malaysia	Hulu Klang	Poland	Lodz
Malaysia	Ipoh	Poland	Plock
Malaysia	Jalan Tun Perak	Poland	Warsaw
Malaysia	Johor Baharu	Portugal	Almada
Malaysia	Kota Kinabalu	Portugal	Cascais
Malaysia	Kuala Lumper	Portugal	Lisbon
Malaysia	Kuala Terengganu	Portugal	Loule
Malaysia	Kuching	Portugal	Lourenco Marque
Malaysia	Likas Bay	Portugal	Loures
Malaysia	Malacca	Portugal	Luanda
Malaysia	Miri	Portugal	Macao
Malaysia	Penang	Portugal	Oeiras
Malaysia	Petaling Jaya	Portugal	Portimao

Table 2.3 (continued): HRBD Represented Countries and Cities

Country	City	Country	City
Portugal	Porto	South Africa	Parow
Portugal	Povoa Varzim	South Africa	Pretoria
Qatar	Doha	Spain	Alicante
Romania	Bucharest	Spain	Andorra
Romania	Timisoara	Spain	Badajoz
Russia	Arkhangelsk	Spain	Badalona
Russia	Erevan	Spain	Barcelona
Russia	Gorky	Spain	Benidorm
Russia	Jalta	Spain	Bilbao
Russia	Kemerovo	Spain	Caceres
Russia	Khabarovsk	Spain	Jerez
Russia	Moscow	Spain	La Coruna
Russia	Naberezhnie	Spain	Las Palmas
Russia	Ordjonikidze	Spain	Logroso
Russia	Orsk	Spain	Madrid
Russia	Rostov-Don	Spain	Malaga
Russia	Sochi	Spain	Orense
Russia	St. Petersburg	Spain	Sevilla
Russia	Togliatti	Spain	Tenerife
Russia	Tula	Spain	Torremolinos
Russia	Uljanovsk	Spain	Valencia
Russia	Volgograd	Spain	Vallaadolid
Russia	Zelenograd	Spain	Zaragoza
Russia	Zhukovsky	Sri Lanka	Colombo
Russia	Zvezdni	Sweden	Gothenburg
Saudi Arabia	Dammam	Sweden	Malmo
Saudi Arabia	Jeddah	Sweden	Stockholm
Saudi Arabia	Jubail	Switzerland	Bale
Saudi Arabia	Makkah	Switzerland	Basel
Saudi Arabia	Mecca	Switzerland	Bern
Saudi Arabia	Medina	Switzerland	Geneve
Saudi Arabia	Riyadh	Switzerland	Lausanne
Saudi Arabia	Sanaa	Switzerland	Montreux
Saudi Arabia	Sharjah	Switzerland	Morges
Scotland	Dundee	Switzerland	Prilly
Scotland	Edinburgh	Switzerland	Regensdorf
Scotland	Glasgow	Switzerland	Renens
Serbia	Belgrade	Switzerland	Winterthur
Singapore	Singapore	Switzerland	Zurich
Slovakia	Bratislava	Syria	Aleppo
Slovakia	Kosice	Syria	Damascus
Slovakia	Martin	Syria	Homs
Slovakia	Povazska Bystr.	Taiwan	Chung Li
Slovenia	Ljubljana	Taiwan	Kaoshiung
South Africa	Bellville	Taiwan	Taichung
South Africa	Cape Town	Taiwan	Taipei
South Africa	Durban	Taiwan	Tao Yuen
South Africa	Goodwood	Thailand	Bangkok
South Africa	Johannesburg	Thailand	N. Ratchasima

Table 2.3 (continued): HRBD Represented Countries and Cities

Country	City	Country	City
Tibet	Lhasa	USA	Cape Canaveral
Turkey	Ankara	USA	Cape Hatteras
Turkey	Iskenderun Bay	USA	Central Islip
Turkey	Istanbul	USA	Charleston
Uganda	Kampala	USA	Charlettesville
Ukraine	Kiev	USA	Charlotte
U.A.E.	Abu Dahbi	USA	Chicago
U.A.E.	Abu Dhabi	USA	Chino Hills
U.A.E.	Dubai	USA	Cincinnati
U.A.E.	Sharjah	USA	Clarendon
Uruguay	Montevideo	USA	Clarksburg
USA	Akron	USA	Clear Lake
USA	Albany	USA	Cleveland
USA	Albuquerque	USA	Cobb County
USA	Alexandria	USA	Cocoa Beach
USA	Alief	USA	Columbia
USA	Allentown	USA	Columbus
USA	Amherst	USA	Connellsville
USA	Anchorage	USA	Corpus Christi
USA	Ann Arbor	USA	Costa Mesa
USA	Arlington	USA	Cranford
USA	Atlanta	USA	Cumberland
USA	Atlantic City	USA	Dallas
USA	Austin	USA	Dayton
USA	Baileys Crossroads	USA	Dearborn
USA	Baltimore	USA	Deerfield
USA	Bangalore	USA	Denver
USA	Bartlesville	USA	Des Moines
USA	Baton Rouge	USA	Detroit
USA	Berkeley	USA	Downers Grove
USA	Berkeley Height	USA	Durham
USA	Bethesda	USA	E.Brunswick
USA	Bethlehem	USA	East Rutherford
USA	Birmingham	USA	Easton
USA	Biscayne Bay	USA	Edgewater
USA	Bloomfield	USA	El Centro
USA	Bloomington	USA	El Paso
USA	Boston	USA	Fairbanks
USA	Bozeman	USA	Fairfax County
USA	Brazoport	USA	Fort Lauderdale
USA	Bridgeport	USA	Fort Wayne
USA	Brighton Beach	USA	Fort Worth
USA	Bristol	USA	Garden Grove
USA	Brooklyn	USA	Glendale
USA	Buffalo	USA	Grand Rapids
USA	Buffalo Grove	USA	Greensboro
USA	Burbank	USA	Greenwood Vill.
USA	Cambridge	USA	Guttenberg
USA	Camden	USA	Harrisburg

Table 2.3 (continued): HRBD Represented Countries and Cities

Country	City	Country	City
USA	Hartford	USA	New Haven
USA	Hoffman Estate	USA	New Orleans
USA	Hollywood	USA	New York
USA	Honesda	USA	Newark
USA	Honolulu	USA	Newport
USA	Houston	USA	Norfolk
USA	Huntington	USA	Normal
USA	Indianapolis	USA	Norman
USA	Iowa City	USA	N. Palm Beach
USA	Irvine	USA	Nutley
USA	Irving	USA	Oak Brook
USA	Itasca	USA	Oakland
USA	Ithaca	USA	Odessa
USA	Jacksonville	USA	Oklahoma City
USA	Jeddah	USA	Omaha
USA	Jersey City	USA	Orange
USA	Johnson City	USA	Orlando
USA	Johnston	USA	Pasadena
USA	Kansas City KS	USA	Peoria
USA	Kansas City MO	USA	Philadelphia
USA	La Jolla	USA	Phoenix
USA	Lake Buena Vista	USA	Pittsburgh
USA	Las Vegas	USA	Port Chester
USA	Lawrence	USA	Portland
USA	Lexington	USA	Prince George's
USA	Lincoln	USA	Providence
USA	Little Rock	USA	Racine
USA	Long Beach	USA	Reading
USA	Long Island	USA	Reston
USA	Los Angeles	USA	Richmond
USA	Louisville	USA	Rochester
USA	Macon	USA	Rock Island
USA	Mahwah	USA	Rockland City
USA	Manchester	USA	Rockville
USA	Manila	USA	Sacramento
USA	Marin County	USA	Salt Lake City
USA	Marina Delray	USA	San Antonio
USA	Mcallen	USA	San Bernardo
USA	Memphis	USA	San Diego
USA	Miami	USA	San Fernando
USA	Milwaukee	USA	San Francisco
USA	Minneapolis	USA	San Jose
USA	Mobile	USA	San Juan
USA	Mt. Pleasant	USA	San Rafael
USA	Muskegon	USA	Santa Ana
USA	Naperville	USA	Santa Clara
USA	Nashville	USA	Seal Beach
USA	Nazareth	USA	Seattle
USA	New Brunswick	USA	Sherman Oaks

Table 2.3 (continued): HRBD Represented Countries and Cities

Country	**City**
USA	Sioux Falls
USA	Southfield
USA	Springfield
USA	St. Louis
USA	St. Luke
USA	St. Paul
USA	Stamford
USA	Stanford
USA	Suffolk
USA	Sylmar
USA	Syracuse
USA	Tallin
USA	Tampa
USA	Tarrytown
USA	Toledo
USA	Topeka
USA	Trenton
USA	Troy
USA	Tucson
USA	Tulsa
USA	Tumon Bay
USA	Upper Macungie
USA	Waikiki
USA	Washington, DC
USA	Weehawken
USA	Weirton
USA	West Palm Beach
USA	White Plains
USA	Whittier
USA	Williams Island
USA	Wilmington
USA	Winston Salem
USA	Worcester
Uzbekistan	Tashkent
Venezuela	Caraballeda
Venezuela	Caracas
Venezuela	Valencia
Vietnam	Ho Chi Minh City
Vietnam	Saigon
West Africa	Lome
Yemen	Aden
Yemen	Wadi Dhahr
Zimbabwe	Harare

Table 2.3A Building Uses (CTBUH, 1981)

Environmental Design
Urban Planning and Design
External Transportation
Parking
Urban Infrastructure
Landscape Architecture
Economics
Ownership and Maintenance
Project Management
Tall Buildings in Developing Countries
Decision-Making Parameters
Development and Investment
Legal Aspects

Table 2.4 Project List

903-14
23Mar98

Schedule 14.__

Council on Tall Buildings and Urban Habitat
Listing of Tall Buildings

Building	**PD #**	**City**	**Year**	**Stories**	**Height m**	**Height ft**	**Material**	**Use**
One Liberty Place	801	Philadelphia	1987	61	287	945	Steel	Office
Two Liberty Place	1426	Philadelphia	1990	58	258	848	Steel	Office
Mellon Bank Center	1185	Philadelphia	1991	54	241	792	Mixed	Office
City Hall	901	Philadelphia	1901	9	178	585	-	Office
1818 Market Street	-	Philadelphia	-	40	152	500	Concrete	Office
Fidelity Mutual Life Building	30	Philadelphia	1971	38	150	492	Steel	Office
PSFS Building	1109	Philadelphia	1932	36	150	491	Mixed	Office
Centre Square	34	Philadelphia	1973	38	149	490	Concrete	Office
5 Penn Center	-	Philadelphia	1970	36	149	488	Concrete	Office
Industrial Valley Bank Building	-	Philadelphia	1969	32	147	482	Concrete	Multiple
Philadelphia National Bank	-	Philadelphia	-	25	145	475	-	Office
2000 Market Street	-	Philadelphia	-	29	133	435	-	Office
Fidelity Bank	-	Philadelphia	-	30	123	405	-	Office
Two Girard Plaza	-	Philadelphia	-	30	123	404	Steel	Office
Lewis Tower	-	Philadelphia	-	33	122	400	-	Office
1500 Locust Street	-	Philadelphia	-	44	119	390	-	
Philadelphia Electric Company	-	Philadelphia	-	27	117	384	-	
I. N. A. Annex	-	Philadelphia	-	27	117	383	-	
Academy House	-	Philadelphia	-	37	115	377	-	Multiple
The Drake	-	Philadelphia	-	33	114	375	-	
Medical Tower	-	Philadelphia	-	33	111	364	-	
State Building	-	Philadelphia	-	18	107	351	-	
United Engineers	-	Philadelphia	-	20	105	344	-	
Packard Building	-	Philadelphia	-	25	104	340	-	
Inquirer Building	-	Philadelphia	-	18	104	340	-	
Dorchester	-	Philadelphia	-	32	103	339	-	
Land Tide Building	-	Philadelphia	-	22	101	331	-	
Suburban Station Budding	-	Philadelphia	-	21	101	330	-	Office
James A. Byme Courthouse	-	Philadelphia	-	22	93	304	Steel	Office
Custom House	-	Philadelphia	1934	17	89	293	Steel	Apartment
1. B. M. Building	-	Philadelphia	1964	21	82	270	Mixed	Office
IBM Building	32	Philadelphia	-	21	82	270	Mixed	Office
Municipal Services Building	55	Philadelphia	1965	16	80	264	Concrete	Office
William J. Green Federal Building	-	Philadelphia	1973	10	61	199	Concrete	Office
Federal Building	-	Philadelphia	1951	11	45	146	-	Office
Richards Medical Research Labs	2586	Philadelphia	1959	7	37	121	Concrete	Multiple
One Meridian Plaza	1695	Philadelphia	-	38	-	-	-	
Central-Penn National Bank	29	Philadelphia	1970	36	-	-	Steel	Office
Penn Mutual Tower	234	Philadelphia	1972	22	-	-	Mixed	Office
Transportation Center	54	Philadelphia	1956	18	-	-	Mixed	Multiple
Stock Exchange Building	31	Philadelphia	1966	14	-	-	Concrete	Office
1650 Market Street	1060	Philadelphia	-	-	-	-	-	
30th Street Station	2227	Philadelphia	1934	-	-	-	-	

Height is measured from sidewalk level of main
entrance to structural top of building.
(Television, radio antennas, and flag poles are not included)

Table 2.5 Professional Specialists List

903-14
23Mar98

Schedule 14.57

Council on Tall Buildings and Urban Habitat
Tall Buildings and the Specialists Involved

Building	Rank	PD #	City	Year	Stories	Height m	ft		Professional Specialists
One Liberty Place	31	801	Philadelphia	1987	61	287	945	A	Murphy - Jahn
								D	Rouse Associates
								E	Otis Elevator Co.
								Ser	Flack & Kurtz
								Str	Lev Zetlin Assocs, Inc.
Two Liberty Place	51	1426	Philadelphia	1990	58	258	848	A	Murphy - Jahn
								A	Zeidler Roberts
Partnership									
								D	Rouse Associates
								E	Otis Elevator Company
								Ser	The ECE Group Ltd.
								Str	Quinn Dressel
Mellon Bank Center	67	1185	Philadelphia	1991	54	241	792	A	Kohn Pedersen Fox
								D	Equitable Life Society
								D	Mellon Bank Corp.
								D	Richard L. Rubin Co.
								Ser	Flack & Kurtz
								Str	Cantor, Office of Irwin
City Hall	295	901	Philadelphia	1901	9	178	585	A	John McArthur Jr.
								A	John Ord
								A	W. Bleddyn Powell
								CM	Erection Public Bldgs
1818 Market Street	—	—	Philadelphia	—	40	152	500		None identified
Fidelity Mutual Life Building	—	30	Philadelphia	1971	38	150	492	A	Vincent G. Kling Ptnrs
								CM	Turner Construction Co.
								D	Fidelity Mutual Corp.
								Ser	Robert J. Sigel, Inc.
								Str	Jackson & Moreland
PSFS Building	—	1109	Philadelphia	1932	36	150	491	A	George Howe
								A	William Lescaze
Centre Square	—	34	Philadelphia	1973	38	149	490	A	Vincent G. Kling Ptnrs
								CM	Tishman Construction
								Sir	Farkas, Barron & Ptns.
5 Penn Center	—	—	Philadelphia	1970	36	149	488		None identified
Industrial Valley Bank Building	—	—	Philadelphia	1969	32	147	482		None identified
Philadelphia National Bank	—	—	Philadelphia	—	25	145	475		None identified
2000 Market Street	—	—	Philadelphia	—	29	133	435		None identified
Fidelity Bank	—	—	Philadelphia	—	30	123	405		None identified
Two Girard Plaza	—	—	Philadelphia	—	30	123	404		None identified
Lewis Tower	—	—	Philadelphia	—	33	122	400		None identified
1500 Locust Street	—	—	Philadelphia	—	44	119	390		None identified

Table 2.5 (continued) Professional Specialists List

Philadelphia Electric Company	—	—	Philadelphia	—	27	117	384	None identified
1. N. A. Annex	—	—	Philadelphia	—	27	117	383	None identified
Academy House	—	—	Philadelphia	—	37	115	377	None identified
The Drake	—	—	Philadelphia	—	33	114	375	None identified
Medical Tower	—	—	Philadelphia	—	33	111	364	None identified
United Engineers	—	—	Philadelphia	—	20	105	344	None identified
Packard Building	—	—	Philadelphia	—	25	104	340	None identified
Inquirer Building	—	—	Philadelphia	—	18	104	340	None identified
Dorchester	—	—	Philadelphia	—	32	103	339	None identified
Land Tide Budding	—	—	Philadelphia	—	22	101	331	None identified
Suburban Station Building	—	—	Philadelphia	—	21	101	330	None identified
James A. Byrne Courthouse	—	—	Philadelphia	—	22	93	304	None identified
Custom House	—	—	Philadelphia	1934	17	89	293	None identified
I. B. M. Building	—	—	Philadelphia	1964	21	82	270	None identified
IBM Building	—	32	Philadelphia	—	21	82	270	A Vincent G. Kling Partners CM Basic Construction Co. D IBM Corporation Str Jackson & Moreland
Municipal Services Building	—	55	Philadelphia	1965	16	80	264	A Vincent G. Kling Partners Ser Charles S. Leopold, Inc. Ser Daniel J. Keating Co. Ser W.M. Anderson Co. Ser Williard Electric Co. Str Thomas J. McCormick
William J. Green Federal Building	—	—	Philadelphia	1973	10	61	199	None identified
Federal Building	—	—	Philadelphia	1951	11	45	146	None identified
Richards Medical Research Labs	—	2586	Philadelphia	1959	7	37	121	A Kahn, Louis
One Meridian Plaza	—	1695	Philadelphia	—	38	—	—	None identified
Central-Penn National Bank Building	—	29	Philadelphia	1970	36	—	—	A Vincent G. Kling Partners Ser Jaros, Baum & Bolles Str McCormick Taylor
Penn Mutual Tower	—	234	Philadelphia	1972	22	—	—	None identified

Table 2.5 (continued) Professional Specialists List

Transportation Center	—	54	Philadelphia	1956	18	—	—	A CM D Ser Str	Vincent G. Kling Partners McCloskey Company PA Tower Building Corp. Robert J. Sigel, Inc. Thomas J. McCormick
Stock Exchange Building	—	31	Philadelphia	1966	14	—	—	A CM Set Sir	Vincent G. Kling Partners Turner Construction Co. Charles S. Leopold, Inc. Allabach and Rennis
1650 Market Street	—	1060	Philadelphia	—	—	—	—		None identified
30th Street Station	—	2227	Philadelphia	1934	—	—	—	A	Graham, Anderson
Bell Atlantic Tower	—	1452	Philadelphia	—	—	—	—		None identified
Carnegie Center	—	1042	Philadelphia	—	—	—	—		None identified
Convention Center	—	1034	Philadelphia	—	—	—	—		None identified
Curtis Center	—	1435	Philadelphia	—	—	—	—		None identified
Eleven Penn Center	—	983	Philadelphia	—	—	—	—		None identified
Franklin Town	—	262	Philadelphia	—	—	—	—		None identified
Gallery 2	—	408	Philadelphia	—	—	—	—		None identified
Insurance Co. of North America	—	1658	Philadelphia	—	—	—	—		None identified
Lit Brothers Department Store	—	1236	Philadelphia	—	—	—	—		None identified
Market Street East Development	—	1033	Philadelphia	—	—	—	—		None identified
Museum of Art	—	2292	Philadelphia	1928	—	—	—	A A	Trambauer, Horace Zantzinger, C. Clark
One Reading Center	—	729	Philadelphia	—	—	—	—		None identified
Penn's Landing	—	1035	Philadelphia	—	—	—	—		None identified
Philadelphia life Building	—	707	Philadelphia	—	—	—	—		None identified
Center City Office Space	—	1032	Philadelphia	—	—	—	—		None identified
Sears Warehouse	—	1954	Philadelphia	—	—	—	—		None identified
Spectrum	—	784	Philadelphia	—	—	—	—		None identified
Twin Skyscrapers	—	989	Philadelphia	—	—	—	—		None identified

Table 2.6 Numerical List

369.290
23Mar98

Schedule 14.1

Numerical List of Project Descriptions

Project Number	Project (Name)	Country	City	See other PD No.
0	Federal Building	USA	Philadelphia	
0	William J. Green Federal Building	USA	Philadelphia	
0	1. B. M. Building	USA	Philadelphia	
0	Custom House	USA	Philadelphia	
0	James A. Byrne Courthouse	USA	Philadelphia	
0	Suburban Station Building	USA	Philadelphia	
0	Land Title Building	USA	Philadelphia	
0	Dorchester	USA	Philadelphia	
0	Inquirer Building	USA	Philadelphia	
0	Packard Building	USA	Philadelphia	
0	United Engineers	USA	Philadelphia	
0	State Building	USA	Philadelphia	
0	Medical Tower	USA	Philadelphia	
0	The Drake	USA	Philadelphia	
0	Academy House	USA	Philadelphia	
0	1. N. A. Annex	USA	Philadelphia	
0	Philadelphia Electric Company	USA	Philadelphia	
0	1 500 Locust Street	USA	Philadelphia	
0	Lewis Tower	USA	Philadelphia	
0	Two Girard Plaza	USA	Philadelphia	
0	Fidelity Bank	USA	Philadelphia	
0	2000 Market Street	USA	Philadelphia	
0	Philadelphia National Bank	USA	Philadelphia	
0	Industrial Valley Bank Building	USA	Philadelphia	
0	5 Penn Center	USA	Philadelphia	
0	1818 Market Street	USA	Philadelphia	
29	Central-Penn National Bank Building	USA	Philadelphia	
30	Fidelity Mutual Life Building	USA	Philadelphia	
31	Stock Exchange Building	USA	Philadelphia	
32	IBM Building	USA	Philadelphia	
34	Centre Square	USA	Philadelphia	
54	Transportation Center	USA	Philadelphia	
55	Municipal Services Building	USA	Philadelphia	
234	Penn Mutual Tower	USA	Philadelphia	
262	Franklin Town	USA	Philadelphia	
408	Gallery 2	USA	Philadelphia	
707	Philadelphia Life Building	USA	Philadelphia	
729	One Reading Center	USA	Philadelphia	
784	Spectrum	USA	Philadelphia	
801	One Liberty Place	USA	Philadelphia	
901	City Hall	USA	Philadelphia	
983	Eleven Penn Center	USA	Philadelphia	

Refer to PD Number listed in this column for information regarding this PD file.

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23Mar98

Schedule 14.1

Numerical List of Project Descriptions

Project Number	Project (Name)	Country	City	See other PD No.
989	Twin Skyscrapers	USA	Philadelphia	
1032	Center City Office Space	USA	Philadelphia	
1033	Market Street East Development	USA	Philadelphia	
1034	Convention Center	USA	Philadelphia	
1035	Penn's Landing	USA	Philadelphia	
1042	Carnegie Center	USA	Philadelphia	
1060	1 650 Market Street	USA	Philadelphia	
1109	PSFS Building	USA	Philadelphia	
1185	Mellon Bank Center	USA	Philadelphia	
1236	Lit Brothers Department Store	USA	Philadelphia	
1426	Two Liberty Place	USA	Philadelphia	
1435	Curtis Center	USA	Philadelphia	
1452	Bell Atlantic Tower	USA	Philadelphia	
1658	Insurance Co. of North America	USA	Philadelphia	
1695	One Meridian Plaza	USA	Philadelphia	
1954	Sears Warehouse	USA	Philadelphia	
2227	30th Street Station	USA	Philadelphia	
2252	Commerce Square	USA	Philadelphia	
2292	Museum of Art	USA	Philadelphia	
2586	Richards Medical Research Labs	USA	Philadelphia	

Table 2.7 Alphabetical List

369.292 Schedule 14.31

23Mar98

Alphabetical List Of Project Descriptions

Project (Name)	Project Number	Country	City	See other PD No.
1500 Locust Street	0	USA	Philadelphia	
1 650 Market Str.	1060	USA	Philadelphia	
1 81 8 Market Street	0	USA	Philadelphia	
2000 Market Street	0	USA	Philadelphia	
30th Street Station	2227	USA	Philadelphia	
5 Penn Center	0	USA	Philadelphia	
Academy House	0	USA	Philadelphia	
Bell Atlantic Tower	1452	USA	Philadelphia	
Carnegie Center	1042	USA	Philadelphia	
Central-Penn National Bank Building	29	USA	Philadelphia	
Centre Square	34	USA	Philadelphia	
City Hall	901	USA	Philadelphia	
Commerce Square	2252	USA	Philadelphia	
Convention Center	1034	USA	Philadelphia	
Curtis Center	1435	USA	Philadelphia	
Custom House	0	USA	Philadelphia	
Dorchester	0	USA	Philadelphia	
Eleven Penn Center	983	USA	Philadelphia	
Federal Building	0	USA	Philadelphia	
Fidelity Bank	0	USA	Philadelphia	
Fidelity Mutual Life Building	30	USA	Philadelphia	
Franklin Town	262	USA	Philadelphia	
Gallery 2	408	USA	Philadelphia	
I. B. M. Building	0	USA	Philadelphia	
I. N. A. Annex	0	USA	Philadelphia	
IBM Building	32	USA	Philadelphia	
Industrial Valley Bank Building	0	USA	Philadelphia	
Inquirer Building	0	USA	Philadelphia	
Insurance Co. of North America	1658	USA	Philadelphia	
James A. Byrne Courthouse	0	USA	Philadelphia	
Land Title Building	0	USA	Philadelphia	
Lewis Tower	0	USA	Philadelphia	
Lit Brothers Department Store	1236	USA	Philadelphia	
Market Street East Development	1033	USA	Philadelphia	
Medical Tower	0	USA	Philadelphia	
Mellon Bank Center	1185	USA	Philadelphia	
Municipal Services Building	55	USA	Philadelphia	
Museum of Art	2292	USA	Philadelphia	
One Liberty Place	801	USA	Philadelphia	
One Meridian Plaza	1695	USA	Philadelphia	
One Reading Center	729	USA	Philadelphia	
Packard Building	0	USA	Philadelphia	
Penn Mutual Tower	234	USA	Philadelphia	
Penn's Landing	1035	USA	Philadelphia	
Philadelphia Electric Company	0	USA	Philadelphia	

- Refer to PD Number listed in this column for information regarding this PD file.

Table 2.7 (continued) Alphabetical List

369.292 Schedule 14.31

23Mar98

Alphabetical List Of Project Descriptions

Project (Name)	Project Number	Country	City	See other PD No.
Philadelphia Life Building	707	USA	Philadelphia	
Philadelphia National Bank	0	USA	Philadelphia	
Center City Office Space	1032	USA	Philadelphia	
PSFS Building	1109	USA	Philadelphia	
Richards Medical Research Laboratories	2586	USA	Philadelphia	
Sears Warehouse	1954	USA	Philadelphia	
Spectrum	784	USA	Philadelphia	
State Building	0	USA	Philadelphia	
Stock Exchange Building	31	USA	Philadelphia	
Suburban Station Building	0	USA	Philadelphia	
The Drake	0	USA	Philadelphia	
Transportation Center	54	USA	Philadelphia	
Twin Skyscrapers	989	USA	Philadelphia	
Two Girard Plaza	0	USA	Philadelphia	
Two Liberty Place	1426	USA	Philadelphia	
United Engineers	0	USA	Philadelphia	
William J. Green Federal Building	0	USA	Philadelphia	

Table 2.8 Geographical List

369.291
23Mar98

Schedule 14.5

Geographical Listing of Project Descriptions

Country	City	Project (Name)	Project Number	See other PD No.
Canada	Vancouver	200 Granville Square	0	
Canada	Vancouver	Board of Trade Tower	0	
Canada	Vancouver	British Columbia Electric Company	3012	
Canada	Vancouver	Canada Trust Tower	383	
Canada	Vancouver	First Bank Tower	0	
Canada	Vancouver	Four Seasons Hotel	0	
Canada	Vancouver	Guinness Tower	0	
Canada	Vancouver	Harbour Centre	0	
Canada	Vancouver	Hotel Vancouver	0	
Canada	Vancouver	Hyatt Regency Hotel	0	
Canada	Vancouver	MacMillan Bloedel Building	0	
Canada	Vancouver	Marine Building	0	
Canada	Vancouver	Martello Tower	0	
Canada	Vancouver	Oceanic Plaza	0	
Canada	Vancouver	Robinson Square	324	
Canada	Vancouver	Royal Bank Tower	0	
Canada	Vancouver	Scotiabank Tower	0	
Canada	Vancouver	Sheraton Landmark Hotel	0	
Canada	Vancouver	Toronto Dominion Bank Tower	0	
Canada	Vancouver	Vancouver Mausoleum Tower	3506	
Canada	Vancouver	West Coast Transmission Company Building	2583	
USA	Bethlehem	Bethlehem Steel	0	
USA	Bethlehem	Broad And Main Renewal	445	
USA	Bethlehem	Homer Research Labs	1161	
USA	Bethlehem	Hotel Bethlehem	0	
USA	Bethlehem	Lutheran Manor	0	
USA	Bethlehem	Martin Tower	582	
USA	Bethlehem	Monacacy Tower	721	
USA	Bethlehem	Moravian House	1601	
USA	Bethlehem	Moravian 11	0	
USA	Bethlehem	One Bethlehem Plaza	192	
USA	Bethlehem	Rooney House	695	
USA	Bethlehem	Unionbank	0	

Refer to PD Number listed in this column for information regarding this PD file.

Table 2.9 The 100 Tallest Buildings in the World (CTBUH, 1998)

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Council on Tall Buildings and Urban Habitat
The One Hundred Tallest Buildings in the World

Height * (Meters/Feet)

Rank	**Building**	**City**	**Year**	**Stories**	**Mat'l**	**Use**	To Structural Top	To Highest Occupied Floor	To Top of Roof	To Tip of Spire/Antenna
1	Petronas Tower I	Kuala Lumpur	UC98	88	Mixed	Multiple	452m / 1483'	375m / 1229'	379m / 1242'	452m/483'
2	Petronas Tower 2	Kuala Lumpur	UC98	88	Mixed	Multiple	452m / 1483'	375m / 1229'	379m / 1242'	452m/1483'
3	Sears Tower	Chicago	1974	110	Steel	Office	442m / 1450'	436m / 1431"	442m / 1450'	520m / 1707'
4	Jin Mao Building	Shanghai	UC98	88	Mixed	Multiple	42 1m / 1380'	366M / 1200'	370m / 1213'	421m/1380'
5	WTC, 1	New York	1972	110	Steel	office	417m / 1368,	413M / 1356'	417m / 1368'	527m / 1728'
6	WTC, 2	New York	1973	110	Steel	Office	415m / 1362'	411m / 1350'	415m / 1362'	415m / 1362'
7	Empire State	New York	1931	102	Steel	office	381m / 1250'	369m / 1212'	381m / 1250'	449m / 1472'
8	Central Plaza	Hong Kong	1992	78	Concrete	Office	374m / 1227'	299m / 981'	309m / 1014'	374m / 1227'
9	Bank of China	Hong Kong	1989	70	Mixed	Office	369m / 1209'	288m / 946'	305m / 1001'	369m / 1209'
10	T & C Tower	Kaoshiung	1997	85	Steel	Multiple	348m / 1140'	341m / 1120'	347m / 1140'	347m /1140'

Table 2.9 (continued) The 100 Tallest Buildings in the World (CTBUH, 1998)

Schedule 1 4.2
Page 2

	Building	City	Year	Stories	Height m	ft	Material	Use
11	Amoco Building	Chicago	1973	80	346	1136	Steel	Office
12	John Hancock Center	Chicago	1969	100	344	1127	Steel	Multiple
13	Shun Hing Square	Shenzhen	1996	69	325	1066	Mixed	Off ice
14	Sky Central Plaza	Guangzhou	1997	80	322	1056	Concrete	Multiple
15	Chicago Beach Tower Hotel	Dubai	UC98	60	321	1053	Mixed	Hotel
16	Baiyoke Tower 11	Bangkok	1997	90	320	1050	Concrete	Hotel
17	Chrysler Building	New York	1930	77	319	1046	Steel	Office
18	NationsBank Plaza	Atlanta	1993	55	312	1023	Mixed	Multiple
19	First Interstate World Center	Los Angeles	1990	75	310	1018	Mixed	Office
20	AT&T Corporate Center	Chicago	1989	60	307	1007	Mixed	Office
21	Texas Commerce Tower	Houston	1982	75	305	1000	Mixed	Off ice
22	Two Prudential Plaza	Chicago	1990	64	303	995	Concrete	Office
23	Ryugyong Hotel	Pyongyang	1995	105	300	984	Concrete	Hotel
24	Commerzbank Tower	Frankfurt	1997	56	299	981	Mixed	Office
25	First Interstate Bank Plaza	Houston	1983	71	296	972	Steel	Office
26	Landmark Tower	Yokohama	1993	70	296	971	Steel	Multiple
27	311 South Wacker Drive	Chicago	1990	65	293	961	Concrete	Office
28	American Internat'l Building	New York	1932	67	290	952	Steel	Office
29	First Canadian Place	Toronto	1975	72	290	951	Steel	Office
30	Society Tower	Cleveland	1991	57	290	950	Mixed	Office
31	One Liberty Place	Philadelphia	1987	61	287	945	Steel	Office
32	Columbia Seafirst Center	Seattle	1984	76	287	943	Mixed	Office
33	40 Wall Street	New York	1930	72	283	927	Steel	Office
34	NationsBank Plaza	Dallas	1985	72	281	921	Mixed	Office
35	Overseas Union Bank Centre	Singapore	1986	66	280	919	Steel	Office
36	United Overseas Bank Plaza	Singapore	1992	66	280	919	Steel	Office
37	Republic Plaza	Singapore	1995	66	280	919	Mixed	Office
38	Citicorp Center	New York	1977	59	279	915	Steel	Multiple
39	Scotia Plaza Toronto	1989	68	275	902	Mixed	Office	
40	Transco Tower Houston	1983	64	275	901	Steel	Office	

Height is measured from sidewalk level of main entrance to structural top of building.
(Television, radio antennas, and flag poles are not included)

Table 2.9 (continued) The 100 Tallest Buildings in the World (CTBUH, 1998)

	Building	City	Year	Stories	Height m	Height ft	Material	Use
41	Renaissance Tower	Dallas	1975	56	270	886	Steel	Office
42	900 North Michigan Avenue	Chicago	1989	66	265	871	Mixed	Multiple
43	NationsBank Corporate Center	Charlotte	1992	60	265	871	Concrete	Office
44	SunTrust Plaza	Atlanta	1992	60	265	871	Concrete	Office
45	Water Tower Place	Chicago	1976	74	262	859	Concrete	Multiple
46	First Interstate Tower	Los Angeles	1974	62	262	858	Steel	Office
47	Canada Trust Tower	Toronto	1990	51	261	856	Mixed	Office
48	Transamerica Corporate Headquarters	San Francisco	1972	48	260	853	Mixed	Office
49	G.E. Building	New York	1933	70	259	850	Steel	Office
50	One First National Plaza	Chicago	1969	60	259	850	Steel	Office
51	Two Liberty Place	Philadelphia	1990	58	258	848	Steel	Office
52	Messeturm	Frankfurt	1990	63	257	843	Concrete	Office
53	USX Tower	Pittsburgh	1970	64	256	841	Steel	Office
54	Rinku Gate Tower	Osaka	1996	56	256	840	-	Multiple
55	Osaka World Trade Center	Osaka	1995	55	252	827	Steel	Office
56	IBM Tower	Atlanta	1987	50	250	820	Mixed	Office
57	BNI City Tower	Jakarta	1995	46	250	820	Concrete	Office
58	Korea Life Insurance Company	Seoul	1985	60	249	817	Steel	Office
59	CitySpire	New York	1989	75	248	814	Concrete	Multiple
60	Rialto Tower	Melbourne	1985	63	248	814	Concrete	Office
61	One Chase Manhattan Plaza	New York	1961	60	248	813	Steel	Office
62	MetLife	New York	1963	59	246	808	Steel	Office
63	Shin Kong Life Tower	Taipei	1993	51	244	801	Mixed	Office
64	Malayan Bank	Kuala Lumpur	1988	50	244	799	Concrete	Office
65	Tokyo City Hall	Tokyo	1991	48	243	797	Mixed	Office
66	Woolworth Building	New York	1913	57	241	792	Steel	Office
67	Mellon Bank Center	Philadelphia	1991	54	241	792	Mixed	Office
68	John Hancock Tower	Boston	1976	60	240	788	Steel	Office
69	Bank One Center	Dallas	1987	60	240	787	Mixed	Office
70	Commerce Court West	Toronto	1973	57	239	784	Mixed	Office

Height is measured from sidewalk level of main entrance to structural top of building.
(Television, radio antennas, and flag poles are not included)

Table 2.9 (continued) The 100 Tallest Buildings in the World (CTBUH, 1998)

	Building	**City**	**Year**	**Stories**	**Height m**	**Height ft**	**Material**	**Use**
71	Moscow State University	Moscow	1953	26	239	784	Steel	Multiple
72	Empire Tower	Kuala Lumpur	1994	62	238	781	Mixed	Off ice
73	NationsBank Center	Houston	1984	56	238	780	Steel	Office
74	Bank of America Center	San Francisco	1969	52	237	779	Steel	Office
75	Worldwide Plaza	New York	1989	47	237	778	Steel	Office
76	IDS Center	Minneapolis	1973	52	236	775	Mixed	Multiple
77	One Canada Square	London	1991	50	236	774	Steel	Office
78	First Bank Place	Minneapolis	1992	58	236	774	Mixed	Office
79	Norwest Center	Minneapolis	1988	57	235	773	Steel	Office
80	Treasury Building	Singapore	1986	52	235	770	Mixed	Multiple
81	191 Peachtree Tower	Atlanta	1991	50	235	770	Mixed	Multiple
82	Opera City Tower	Tokyo	1997	54	234	768	-	Multiple
83	Shinjuku Park Tower	Tokyo	1994	52	233	764	Steel	Multiple
84	Heritage Plaza	Houston	1987	52	232	762	Steel	Office
85	Kompleks Tun Abdul Razak Build.	Penang	1985	65	232	760	Concrete	Office
86	Palace of Culture and Science	Warsaw	1955	42	231	758	Mixed	Office
87	Carnegie Hall Tower	New York	1991	60	231	757	Concrete	Office
88	Three First National Plaza	Chicago	1981	57	230	753	Mixed	Office
89	Equitable Tower	New York	1986	51	229	752	Steel	Office
90	MLC Centre	Sydney	1978	65	229	751	Concrete	Office
91	One Penn Plaza	New York	1972	57	229	750	Steel	Office
92	1251 Avenue of the Americas	New York	1972	54	229	750	Steel	Office
93	Prudential Center	Boston	1964	52	229	750	Steel	Office
94	Two California Plaza	Los Angeles	1992	52	229	750	Steel	Office
95	Gas Company Tower, The	Los Angeles	1991	54	228	749	Steel	Office
96	Two Pacific Place/Shangri-La Hotel	Hong Kong	1991	56	228	748	Concrete	Multiple
97	1100 Louisiana Building	Houston	1980	55	228	748	Mixed	Office
98	Korea World Trade Center	Seoul	1988	54	228	748	Steel	Multiple
99	Governor Phillip Tower	Sydney	1993	64	227	745	Mixed	Office
100	J.P. Morgan Headquarters	New York	1992	56	227	745	Steel	Office

Height is measured from sidewalk level of main entrance to structural top of building.
(Television, radio antennas, and flag poles are not included)

Table 2.9 (continued) The 100 Tallest Buildings in the World (CTBUH, 1998)

Appendix A

Schedule 14.2
Page 5

The One Hundred Tallest Buildings in the World

SUMMARY & FACT SHEET

Tallest Building in the World...

	Building Name	Location	Height Meters	Height Feet
...to Structural Top:	Petronas Tower 1	Kuala Lumpur	452	1483
...to Highest Floor:	Sears Tower	Chicago	436	1431
... to Top of Roof:	Sears Tower	Chicago	442	1450
... to Tip of Spire or Antenna:	World Trade Center, One	New York	527	1728

Top Ten Countries,Cities, and Regions Represented in 100 Tallest List

Country	No. of Buildings.	City	No. of Buildings.	Region	No. of Buildings
USA	59	New York	18	Africa	0
Japan	6	Chicago	10	Asia	29
Malaysia	5	Houston	6	Europe	4
Canada	4	Los Angeles	4	Mid East	1
Singapore	4	Kuala Lumpur	4	North America	63
Korea	3	Atlanta	4	Oceania	3
China	3	Toronto	4	South America	0
Hong Kong	3	Singapore	4		
Australia	3	Tokyo	3		
Taiwan	2	Philadelphia	3		
Others	8	Others	40		
Total No. of Countries:	1 7	Total No. of Cities:	38		

Other Statistics

Date of Construction	No. of Buildings	Material	No. of Buildings	Useage	No. of Buildings
Currently under contruction:	4	Concrete	17	Hotel	3
1990s:	38	Mixed	32	Multiple Use	20
1980s:	27	Steel	45	Office	76
1970s:	17			Residential	0
1960s:	6				
1950s:	2				
1940s:	0				
1930s:	5				
Before 1930:	1				

Table 2.9 (continued) The 100 Tallest Buildings in the World (CTBUH, 1998)

Appendix B

Schedule 14.2
Page 6

The One Hundred Tallest Buildings in the World
UNDER CONSTRUCTION

The following list contains buildings that are currently under construction, but are not yet "topped-out" (the point of construction when the structure has met its proposed *structural top).* The buildings are listed by height, and they are ranked according to where they would fall on the official 100 Tallest list if they were topped-out today.

Rank	Building Name	City	Year	Stories	Meters	Feet	Material	Use
1	Suyong Bay Tower 88	Pusan	UC02	88	462	1516	-	Multiple
1	Shanghai World Financal Center	Shanghai	UC01	95	460	1509	-	Multiple
4	Sudirman Office & Ritz Carlton	Jakarta	UC00	81	427	1400	Mixed	Multiple
7	Plaza Rakyat	Kuala Lumpur	UC98	77	382	1254	Concrete	office
18	BDNI Center - Tower A	Jakarta	UC99	62	317	1040	Mixed	Office
27	The Centre	Hong Kong	UC98	69	292	958	Steel	Office
33	Nanjing Xi Lu	Shanghai	UC98	62	281	92	Concrete	Multiple
47	Tianjin World Trade Center	Tianjin	UC99	64	260	853	-	Multiple
58	Al Falsaliah Centre	Riyadh	UC00	-	250	820	-	Office
70	BDNI Center - Tower B	Jakarta	UC99	45	240	788	Mixed	Office
71	JR Central Towers	Nagoya	UC99	53	240	787	-	Multiple
72	Graha Kuningan	Jakarta	UC98	52	239	784	Mixed	Multiple
98	Wing Lok Tower	Hong Kong	UC98	54	228	748	Steel	office

Table 3.1 CTBUH Topical Groups and Committees

Urban Systems
Environmental Design
Urban Planning and Design
External Transportation
Parking
Urban Infrastructure
Landscape Architecture

Development and Management
Economics
Ownership and Maintenance
Project Management
Tall Buildings in Developing Countries
Decision-Making Parameters
Development and Investment
Legal Aspects

Planning and Architecture
Philosophy of Tall Buildings
History of Tall Buildings
Architecture
Social Effects of the Environment
Socio-Political Influence
High-Rise Housing
Design for the Disabled and Elderly
Interior Design

Systems and Concepts
Structural Systems
Construction
Foundation
Cladding
Partitions, Walls, and Ceilings
Rehabilitation, Renovation, and Repair
Industrial Buildings
High-Tech Buildings
Prefabricated Tall Buildings
Robots and Tall Buildings
Security Systems

Table 3.1 (continued) CTBUH Topical Groups and Committees

Building Service Systems
Vertical and Horizontal Transportation
HVAC
Electrical Systems
Plumbing and Fire Protection
Energy
Indoor Air Quality

Criteria and Loading
Gravity Loads and Temperature Effects
Earthquake Loading and Response
Wind Loading and Wind Effects
Fire Safety
Accidental Loading
Safety and Serviceability
Quality Assurance
Motion Perception and Tolerance

Tall Steel Buildings
Commentary on Structural Standards
Analysis and Design
Stability
Connections
Cold-Formed Steel
Mixed Construction

Tall Concrete and Masonry Buildings
Commentary on Structural Standards
Analysis and Design
Precast Concrete
Stability
Stiffness and Crack Control
Creep, Shrinkage, and Temperature Effects
Masonry Structures
Prestressed Concrete

Table 3.2 Loading Systems

Gravity
Temperature
Earthquake
Wind
Fire
Accidental Loading
Water and Snow

Table 3.3 Functional Systems

Utilization	Parking
(commercial, residential)	Ownership, Financing
Ecological	Operation
Site	Maintenance
Esthetics	Management
Space Cognition	Building Services
(signing)	Communication
Access and Evacuation	Security
Infiltration Protection	Fire Protection
Environmental	Urban Services
Transportation	Energy Efficiency

Table 3.4 Physical Systems

Foundation	Architectural (cladding,
Structural Framework	(walls and partitions,
Mechanical and Service Systems	floors, ceilings)
Electrical	Fittings and Furnishings
Utilities	Contents

Table 3.5 Building Implementation Systems

Need
Development
Planning
Design
Construction
Operation
Demolition

Table 4.1 Factors Influencing the Selection of Structural Systems

Materials	Function
Location, Region of the World	Esthetics
Economy	Architecture
Loading	Conversion Ability
Zoning	Geometry
Services	Analysis

Table 4.2 Future Vision Projects

Building	**City**	**Year**	**Stories**	**Height** **m**	**ft**
X-Seed 4000	Tokyo Bay	-	800	4000	13123
Try 2004	Tokyo	-	400	2004	6573
Aeropolis 2001	Tokyo Bay	-	500	2001	6565
Illinois (Mile High)	Chicago	-	528	1610	5280
Pyramid-In-Pyramid	Singapore	-	-	1500	4920
Mother	Tokyo	-	220	1321	4334
Sky City 1000	Tokyo	-	196	1000	3280
Seiren 21	Konoike	-	180	880	2887
Dynamic Intelligent Building	Tokyo	-	200	800	2625
Millennium Tower	Tokyo	-	150	800	2625
Proposed 2300 Feet Tower	Chicago	-	169	701	2300
T-Growth	Taisei	-	170	700	2297
Tokyo Millennium Tower	Tokyo	-	150	840	2756
Aquarius	-	-	200	800	2625
Super Pyramid	-	-	195	1000	3281

Height is measured from sidewalk level of main
entrance to structural top of building.
(Television, radio antennas, and flag poles are not included)

Table 5.1 Structural Systems (Falconer and Beedle, 1984)

Primary Structural Framing System

Bearing Wall
Core
Frame
Tube

Augmentative Structural Subsystems

Structural Wall
Structural Core
Truss System
Repeated Girder
Moment Resisting Frame

Floor Framing Subsystems

Steel
Concrete
Composite

Table 5.1A Primary Systems: A Breakdown

Bearing Wall

Bearing Wall
Bearing Wall and Core
Bearing Wall and Frame

Core

Perimeter Core
Core with Suspended Floors
Core with Cantilevered Floors
Central Core
Offset Core
Perimeter Core and Frame
Core with Suspended Floors and Frame
Core with Cantilevered Floors and Frame
Central Core and Frame
Offset Core and Frame
Perimeter Core and Shear Walls
Core w/ Suspended Floors & Shear Walls
Core w/ Cantilevered Floors & Shear Walls
Central Core and Shear Walls
Offset Core and Shear Walls
Perimeter Core and Central Core

Frame

Simple Frame
Semi-Rigid Frame
Rigid Frame
Simple Frame and Shear Walls
Semi-Rigid Frame and Shear Walls
Rigid Frame and Shear Walls
Simple Frame and Solid Core
Semi-Rigid Frame and Solid Core
Rigid Frame and Solid Core
Exterior Truss Frame
Simple Frame and Braced Frame
Semi-Rigid Frame and Braced Frame
Rigid Frame and Braced Frame

Table 5.1 (continued) Structural Systems (Falconer and Beedle, 1984)

	Tube
Framed Tube	Perforated Shell Tube-in-Tube
Trussed Tube	Framed Tube with Interior Columns
Deep Spandrel Tube	Trussed with Interior Columns
Perforated Shell Tube	Deep Spandrel Tube with Interior Columns
Framed Tube-in-Tube	Perforated Shell Tube with Interior Columns
Trussed Tube-in-Tube	Bundled (Modular) Tube
Deep Spandrel Spandrel Tube-in-Tube	

Table 5.2 Bracing Subsystem Classification (Falconer and Beedle, 1984)

<u>Frame Bracing</u>
- Concentrically Braced Frame
- Single Diagonal Bracing
- Double Diagonal Bracing
- Horizontal K Bracing
- Vertical K Bracing
- Knee Bracing
- Lattice Bracing
- Eccentrically Braced Frame
- Eccentric Diagonal Bracing
- Eccentric K Bracing

<u>Moment Resisting Frames</u>
- Ordinary Moment Resistant Frame
- Ductile Moment Resisting Frame
- Ductile Moment Resisting Frame (Dual System)

<u>Shear Wall Bracing</u>
- Simple Shear Wall
- Coupled Shear Wall
- Ductile Shear Wall
- Ductile Simple Shear Wall
- Ductile Coupled Shear Wall

<u>Hat and/or Belt Truss</u>
- Single Diagonal Belt/Hat
- Double Diagonal Belt/Hat

Table 5.2 (continued) Bracing Subsystem Classification (Falconer and Beedle, 1984)

Steel Core Bracing
- Concentrically Braced Core
- Single Diagonal Bracing
- Double Diagonal Bracing
- Horizontal K Bracing
- Vertical K Bracing
- Knee Bracing
- Lattice Bracing
- Eccentrically Braced Core
- Eccentric Diagonal Bracing
- Eccentric K Bracing

Steel Core Bracing
- Simple Core
- Coupled Core
- Ductile Core
- Ductile Simple Core
- Ductile Coupled Core

Table 5.3 Floor Framing Subsystem Classification (Falconer and Beedle, 1984)

Steel	Concrete	Composite
Pre-Fabricated	Flat Slab	Steel Beam and Slab
Steel Beam and Deck	Flat Plate	Steel Joist and Slab
Steel Joist and Deck	Waffle Slab	Steel Beam, Slab Metal Deck
	Beam and Slab	Steel Joist, Slab Metal Deck
	Joist and Slab	Concrete Encased Beam
	Joist and Slab (one way)	
	Joist and Slab (two way)	

Table 5.4 Structural Material Systems Classification (Falconer and Beedle, 1984)

Primary Material
- Steel
- Concrete
- Mixed

Material in Framing System
- Unreinforced Masonry
- Reinforced Masonry
- Reinforced Monolithic Concrete
- Prestressed Monolithic Concrete
- Reinforced Precast Concrete

Table 5.4(continued)Structural Material Systems Classification(Falconer and Beedle,1984)

Prestressed Precast Concrete
Mixed Concretes
Structural Steel
High Strength Steel
Mixed Steels
Mixed Construction - Composite
Mixed Systems
Vertically Mixed
Wood

Material in Core Subsystem
Reinforced Monolithic Concrete
Prestressed Monolithic Concrete
Reinforced Precast Concrete
Prestressed Precast Concrete
Structural Steel
High Strength Steel

Table 5.5 Mechanical Systems Classification (Falconer and Beedle, 1984)

H.V.A.C. Classification

Heating Subsystems
Forced Air
Steam Heating
Electric Panels
All Water
Combination

Air Conditioning Subsystems (Cooling)
All-Air
Air-Water
All-Water
Multiple Unit
Combination

Main Plumbing System Classification
Pressure Boosting Systems
Hot Water Supply Systems
Chilled Water Systems

Table 5.5A Additional Mechanical Systems Classification (Falconer and Beedle, 1984)

Vertical Transportation Systems Classification

Escalators	Elevators: Car and Traffic Flow	Elevators: Drive and Shaft	Material Movers
Parallel	Single Deck, Local Service	Geared Traction, In-Line Elevator Shaft	Pneumatic Tubes
Multiple Parallel	Single Deck, Express Service	Geared Traction, Opposite Elevator Shaft	Vertical Box
Parallel Separated	Single Deck, Sky Lobby	Gearless Traction, In-Line Elevator Shaft	Conveyors
Criss-Cross	Double Deck, Local Service	Gearless Traction, Opposite Elevator Shaft	
Criss-Cross Separated	Double Deck, Express Service		
	Double Deck, Sky Lobby		

Table 5.6 Architectural Systems Classification (Falconer and Beedle, 1984)

Cladding Systems Classification

Cladding and Glass Type	Cladding Material	Installation Method
Custom Clad, Clear Glass	Struct. Carbon Steel	Stick Installation
Custom Clad, Tinted Glass	Stainless Steel	Unit Installation
Custom Clad, Opaque Glass	Aluminum	Unit and Mullion Installation
Standard Clad, Clear Glass	Bronze	Panel Installation
Standard Clad, Tinted Glass	Stone	Column and Spandrel Cover Installation
Standard Clad, Opaque Glass	Concrete	
	Brick	
	Ceramic Tile	

Partition Systems Classification

Permanent	Demountable
Masonry Brick	Wood Frame (Post) and Infill Panels
Concrete Block	Metal Frame (Post) and Infill Panels
Monolithic Concrete	Wood Frame (Post) and Overlay Panels
Stone	Metal Frame (Post) and Overlay Panels
Precast Panel	Postless

Table 5.7 Structural Systems Monograph "Classification" (CTBUH, 1995)

Braced Frames
Moment Resisting Frames
Shear Wall Systems
Core and Outrigger Systems
Tubular Systems
Hybrid Systems

Table 5.8 Structural Systems Classification (Taranath, 1988)

Semi-Rigid Frame
Rigid Frame
Braced Frame
Staggered Truss
Eccentric Bracing System
Interacting Braced & Rigid Frames
Outrigger & Belt Truss System
Framed Tube
Trussed Tube
Cellular Tube
High Efficiency Systems
Flat Slab & Shear Walls
Coupled Shear Walls
Widely Spaced Perimeter Tubes
Core Supported Structures
Exterior Diagonal Tube
Bundled (Modular Tube)

Table 5.9 Structural Systems Classification (Smith and Coull, 1991)

Braced Frame
Rigid Frame
Infilled Frame and Flat Plate
Shear Wall
Wall Frame
Framed Tube
Outrigger Braced
Suspended
Core
Space
Hybrid

Table 5.10 Structural Systems Terminology

Christiansen, "CIP RC Systems," Planning & Design of Tall Buildings, 1979-1981

Boxed Frame	Slitted Panel
Framed Tube	Single Diagonally Braced Frame
Moment Resisting Frame	Double Diagonally Braced Frame
Bearing Wall	K Braced Frame
Infilled Panel	Tube-in-Tube
Shear Wall	

Kavychine, "RC, Precast & Prestressed," Planning & Design of Tall Buildings, 1979

Cores	Frames

Robertson, "Theme Report," Planning & Design of Tall Buildings, 1979-81

Tubular Concept	Tube-in-a-Tube
Vierendeel System	Bundled

Iyengar, "Composite High-Rise Systems," Advances in Tall Buildings, 1986

Exterior Tubular System	Exterior Framed Tube
Core Braced System	Shear Wall Core Tube
Composite Tubular System	Punched Wall (Framed Tube)
Tube-in-Tube	Shear-Wall, Braced Core, Frame

Iyengar, "Composite Tubular Buildings," Advances in Tall Buildings, 1986

Tubular	Shear Wall
Tube-in-Tube	Punched Framed Tube
Bundled Tube	Exterior Framed Tube

Iyengar, "An Update," Advances in Tall Buildings, 1986

Tubular Concept	Perimeter Framed Tube
Plane Frame	Framed Tube
Shear Wall	Braced Tube
Vertical Truss	Bundled Tube
Belt Truss - Outrigger	Mega-Structure
Punched Tube	Superframe
Tube-in-Tube	Exterior Diagonal System

Iyengar, High-Rise Buildings: Recent Progress, 1986

Core Braced	Exterior Framed Tube
Shear Wall and/or Punched Wall	Tube-in-Tube
Framed Tube	Superframe System
Moment Resisting Frame	

Table 5.10 (continued) Structural Systems Terminology

Moore & Gosain, High-Rise Buildings: Recent Progress, 1986	
Shear Walls	K Braced Frame
Exterior Tube	Moment Frame
Wong, Youseff & Kung, High-Rise Buildings: Recent Progress, 1986	
Moment Frame	Frame with Trussed Tube
Rigid or Braced Frame	Bundled Tube
Exterior Framed Tube	Dual System
Framed Tube with Braced Frame	Concentric Braced Frames
Framed Tube	Eccentrically Braced Frames
Mixed System	Outrigger System
Iyengar, "Composite & Steel High-Rise Systems," Habitat & the High-Rise: Tradition & Innovation, 1995	
Shear Frame	Superframe
Shear Truss	Shear Wall
Shear Truss-Frame System with Outriggers	Frame-Shear Wall System
Framed Tube	Core with Outrigger
Modular Tube	Exterior & Interior Diagonalized System
Trussed Tube	Bundled Tube
Other Literature	
Bundled Tube with Core	Southeast Financial Center
Framed Tube	Chestnut DeWitt Apartments
Tube-in-Tube	First Canadian Centre
Bundled Framed Tube	One Magnificent Mile
Bundled Tube	Crocker Center
Framed Tube	60 State Street
Framed Tube	Gateway III
Slab and Shear Wall	Super Montparnasse
Two End Cores, Internal Shear Wall	Pirelli Building
Two End Cores, Internal Shear Wall	Centre Point Building
Central Core, Suspended Floors	Johnson Wax Research Tower
Central Core	Hide Tower
Core and Perimeter Frame	Australia Square
Core with Cantilevered Floors	Standard Bank Centre
Exterior Shear Walls	Tolworth Office Building
Exterior Shear Walls	Toronto City Hall
Braced Core, Shear Wall Infills, Exterior Moment Frame	Tower 49

Table 5.11 Project Descriptions (CTBUH, 1998)

Structural System Description	Building Name
concrete core with exterior frame and outrigger	Petronas Tower 1
concrete core with exterior frame and outrigger	Petronas Tower 2
bundled tube; tubular system	Sears Tower
concrete core wall with exterior frame; outrigger	Jin Mao Building
framed tube	World Trade Center, 1
framed tube	World Trade Center, 2
externally cross-braced moment framed tube with core	Central Plaza
cross braced steel truss; space truss	Bank of China Tower
eccentrically braced ductile steel frame with outriggers	T & C Tower
perimeter framed tube	Amoco Building
diagonally braced perimeter steel framed tube	John Hancock Center
core wall with external columns & outriggers; steel rigid frame & core wall with belt trusses	Shun Hing Square
concrete core walls, external concrete-filled tube columns; outriggers; tube-in-tube with core	Sky Central Plaza
internal braced core and perimeter ductile frame	First Interstate World Center
framed tube	AT&T Corporate Center
perimeter steel frame tube, massive columns at each corner linked together with vierendeel trusses	Commerzbank Tower
tubular	First Interstate Bank Plaza
moment frame, core bracing, large perimeter columns	Columbia Seafirst Center
exterior frame	NationsBank Plaza
diagonally braced core; triangular truss bracing, outrigger, perimeter frame, hat truss	J.P. Morgan Headquarters

903-14
20ct96

Table 6.1 Current Council Tall Building Survey Form

Schedule 14.6

COUNCIL ON TALL BUILDINGS AND URBAN HABITAT

Lehigh University
13 East Packer Avenue
Bethlehem, PA 18015-3191 USA
610/758-3515 • Fax: 610/758-4522 • E-mail: inctbuh@lehigh.edu

DATE: ________

BUILDING HEIGHTS AND OTHER CHARACTERISTICS
Survey Form

- Please list the tall buildings with which your firm has been involved.
- See the reverse side of this form for column heading key. Please return as soon as possible
- Provide photographs where available. Use additional sheets as needed.

City, Country	Building Name & Address	Stories	Height (enter in feet or meters)				Year	Material	Use	Service your firm provided	Notes, Events	Encl.? (Y/N)	
			Structural Top	Highest Occupied Floor	Top of Roof	Tip of Tower or Spire						Fact Sheet	Photo
(SAMPLE) Anytown, USA	Merchant's Bank 3400 Main Street	14/3	447'	415'	426'	447'	1967	Concrete	Office	Structural Engineering	Tallest in city	N	Y

Respondent's Name and Address: ________

Table 6.1 (continued)Current Council Tall Building Survey Form

KEY

The definition of a tall building is relative, but for the purpose of this survey list those building nine or more stories in height. (Height is measured from sidewalk level of main entrance to structural top of building, including spire. Television, radio antennas, and flag poles are *not* included.)

COLUMN HEADING	DEFINITION
City, Country	City, Country (State, Province) where the building is located.
Building Name and Address	Official name of the building and the complete street address.
Stories	Stories both above and below ground level: (Stories above ground / stories below ground).
Height	Height in feet or meters.(All height categories are measured from sidewalk level of main entrance.)
TO STRUCTURAL TOP	Height to structural top of building. Spires are included. Television, radio antennas, and flag poles are *not* included.
TO HIGHEST OCCUPIED FLOOR	Height to the floor of the highest occupied floor of the building.
TO TOP OF ROOF	Height to the top of the roof of the highest occupied floor of the building.
TO TIP OF TOWER/SPIRE	Height to the tip of the spire, pinnacle, antenna, mast, or flag pole.
Year Completed	Year in which the construction of the building was completed.
Material	Steel, concrete, mixed, masonry, timber, etc. Also note where there are variations with height.
Use	The Council's defines a tall building as a structure inhabited by people for various purposes. This includes the following categories and uses (please identify the building by use, not category):
Category	**Use**
COMMERCIAL	office, stores and shops, bank, public utility
RESIDENTIAL	apartment (rental and condominium), hotel, dormitory, hostel
INDUSTRIAL	warehouse, manufacture ("flattened factory"), laboratory, library, museum, correctional institution, court of law, religious edifice.
PUBLIC ASSEMBLY	Theater, hall, auditorium (meeting rooms), restaurant, observation.
SPECIAL PURPOSE	transportation (air, rail, bus, ship), garage/parking, mausoleum.
MULTIPLE USE	megastructures that are various combinations of the above.
Service Your Firm Provided	If you are entering this information on behalf of a specific firm, what was the firm's involvement with the building (architect, services engineer, elevator manufacturer, developer)?
Notes, Events	Please list any interesting facts about the building, or any unusual event that involved the building (earthquake, wind, fire, blast, extreme vandalism).
Enclosure? (fact sheet/photo)	If your firm can supply a fact sheet and/or a photograph of the building, please denote the proper column with "Y" and enclose the material.

Table 7.1 Suggested Classification System

<u>Cores</u>
Interior Core
Two End Cores
Three End Cores
Interior and Four Corner Cores
Interior Core with Cantilevered Floors
Interior Core with Suspended Floors

<u>Frames</u>
Moment Resisting Frame
Braced Frame

<u>Tubes</u>
Framed Tube
Trussed Tube
Bundled Tube
Framed Tube-in-Tube
Trussed Tube-in-Tube

<u>Walls</u>
Gravity Load Bearing Wall
Interior Shear Wall
Exterior Shear Wall
Infilled Panel

<u>Combinations (Hybrid Systems)</u>

903-14
28Apr98

Table 8.1 Proposed Council Tall Building Survey Form

Schedule 14.6

COUNCIL ON TALL BUILDINGS AND URBAN HABITAT

Lehigh University
13 East Packer Avenue
Bethlehem, PA 18015-3191 USA
610/758-3515 • Fax: 610/758-4522 • E-mail: inctbuh@lehigh.edu

DATE: ________

BUILDING HEIGHTS AND OTHER CHARACTERISTICS
Survey Form

- Please list the tall buildings with which your firm has been involved.
- See the reverse side of this form for column heading key. Please return as soon as possible
- Provide photographs where available. Use additional sheets as needed.

City, Country	Building Name & Address	Stories	Height (enter in feet or meters)				Year	Material	Use	Structural System	Service your firm provided	Notes, Events	Encls. (Y/N)	
			Structural Top	Highest Occupied Floor	Top of Roof	Tip of Tower or Spire							Fact Sheet	Photo
(SAMPLE) Anytown, USA	Merchant's Bank 3400 Main Street	14/3	447'	415'	426'	447'	1967	Concrete	Office	Interior and Four Corner Cores	Structural Engineering	Tallest in city	N	Y

Respondent's Name and Address: ____________________

Table 8.1 (continued) Proposed Council Tall Building Survey Form

KEY

The definition of a tall building is relative, but for the purpose of this survey list those building nine or more stories in height. (Height is measured from sidewalk level of main entrance to structural top of building, including spire. Television, radio antennas, and flag poles are *not* included.)

COLUMN HEADING	DEFINITION
City, Country	City, Country (State, Province) where the building is located.
Building Name and Address	Official name of the building and the complete street address.
Stories	Stories both above and below ground level: (Stories above ground / stories below ground).
Height	Height in feet or meters.(All height categories are measured from sidewalk level of main entrance.)
TO STRUCTURAL TOP	Height to structural top of building. Spires are included but television, radio antennas, and flag poles are *not*.
TO HIGHEST OCCUPIED FLOOR	Height to the floor of the highest occupied floor of the building.
TO TOP OF ROOF	Height to the top of the roof of the highest occupied floor of the building.
TO TIP OF TOWER/SPIRE	Height to the tip of the spire, pinnacle, antenna, mast, or flag pole.
Year Completed	Year in which the construction of the building was completed.
Material	Steel, concrete, mixed, masonry, timber, etc. Also note where there are variations with height.
Use	The Council's defines a tall building as a structure inhabited by people for various purposes: (please identify the building by use, not category):
Category	**Use**
COMMERCIAL	office, stores and shops, bank, public utility
RESIDENTIAL	apartment (rental and condominium), hotel, dormitory, hostel
INDUSTRIAL	warehouse, manufacture, laboratory, library, museum, correctional institution, court of law, religious edifice.
PUBLIC ASSEMBLY	Theater, hall, auditorium (meeting rooms), restaurant, observation.
SPECIAL PURPOSE	transportation (air, rail, bus, ship), garage/parking, mausoleum.
MULTIPLE USE	megastructures that are various combinations of the above.
Structural System	The typical structural systems categories are as follow (include other elements such as bracing, ouriggers, belt trusses, interior columns or slitted shear walls):
Primary Category	**Subcategories**
CORES	interior core, two end cores, three corner cores, interior and four corner cores, interior core with suspended floors, interior core with cantilevered floors.
FRAMES	moment resisting frame, braced (shear) frame.
TUBES	bundled tube, framed tube, trussed tube, framed tube-in-tube, trussed tube-in-tube.
WALLS	gravity load bearing wall, interior shear wall, exterior wall, infilled panel.
Service Your Firm Provided	If applicable, what was the firm's involvement with the building (architect, services engineer, developer, etc.)?
Notes, Events	Please list any interesting facts about the building, or any unusual event that involved the building (earthquake, wind, fire, blast, extreme vandalism).
Enclosure? (fact sheet/photo)	If your firm can supply a fact sheet and/or a photograph of the building, please denote the proper column with "Y" and enclose the material.

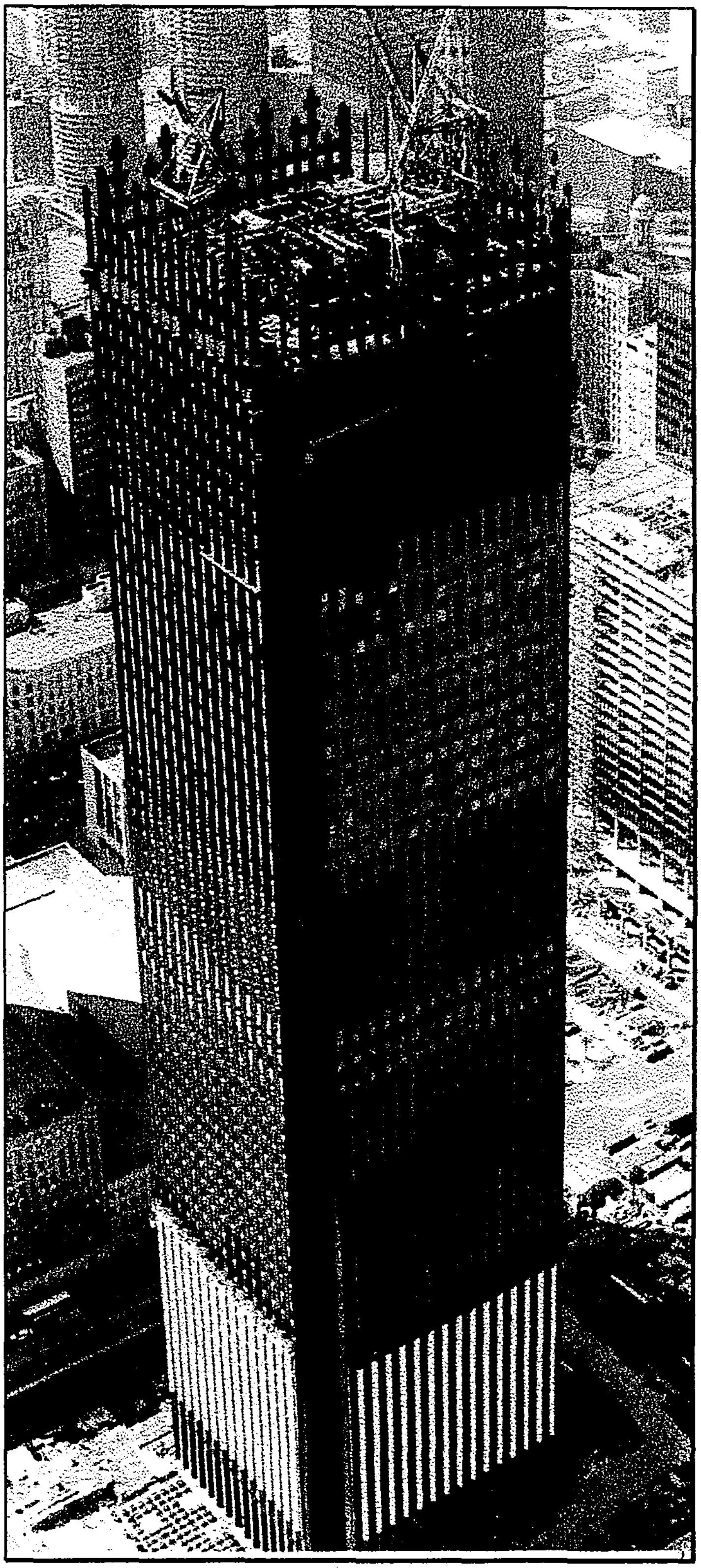

Fig. 4.1 Amoco Building, Chicago
(Framed Tube)

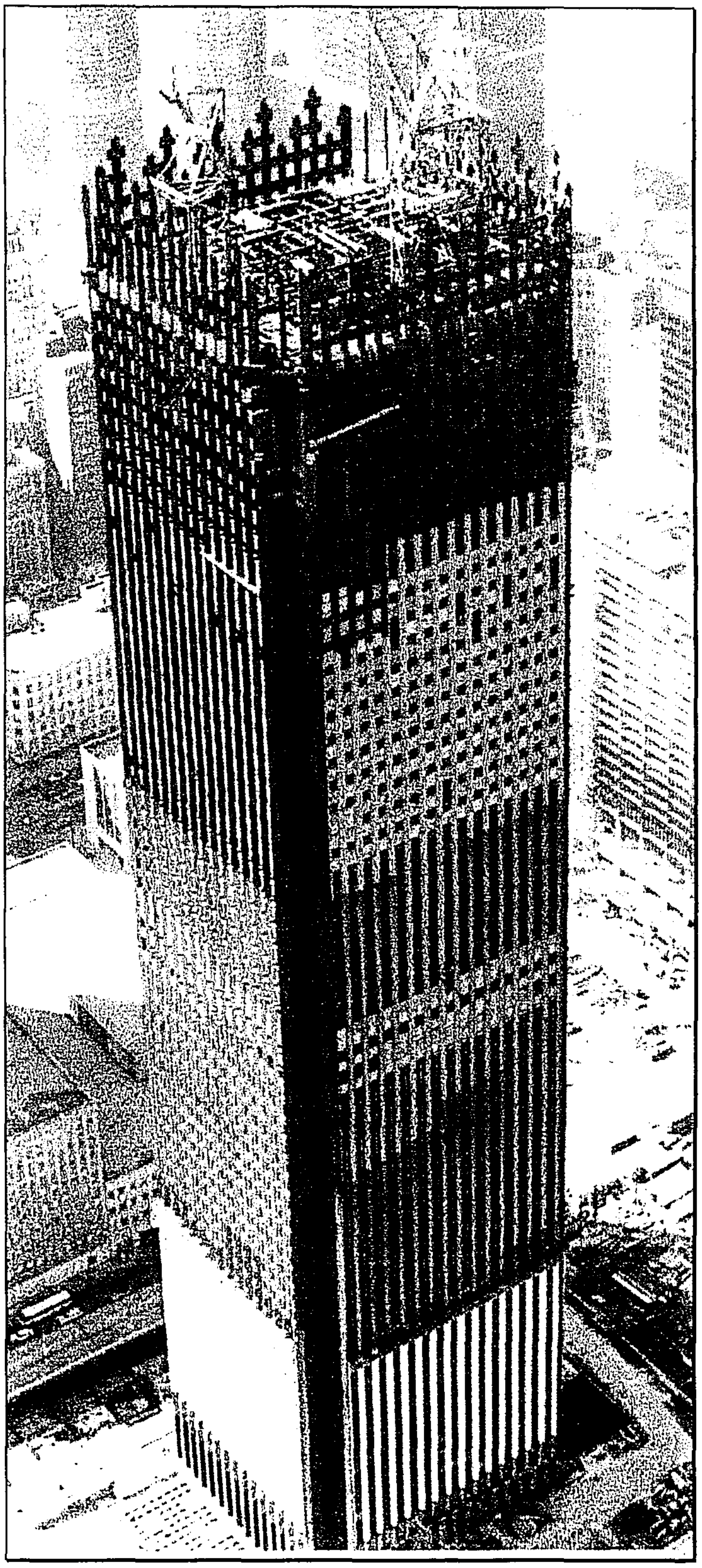

Fig. 4.1 Amoco Building, Chicago
(Framed Tube)

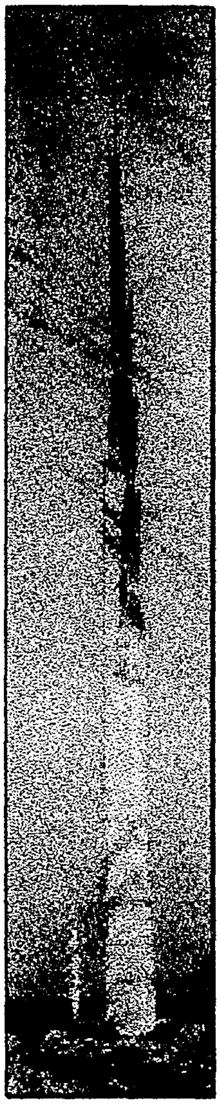

Fig. 4.2 Mile High Tower
(Future Vision)

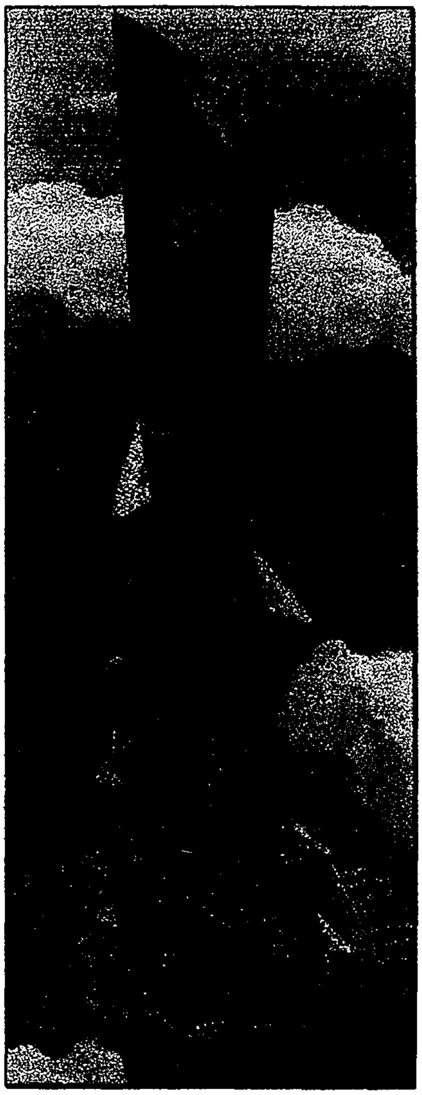

Fig. 4.3 Aeropolis
(Future Vision)

Fig. 4.2 Mile High Tower
(Future Vision)

Fig. 4.3 Aeropolis
(Future Vision)

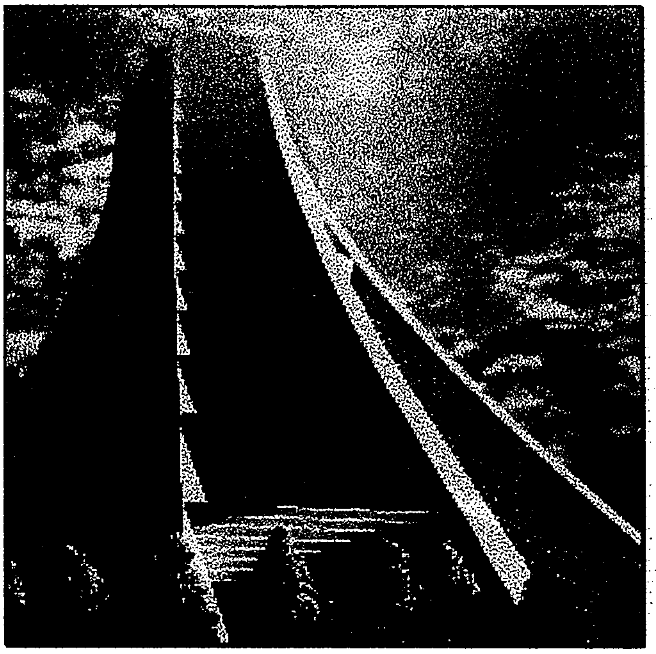

Fig. 4.4 Sky City 1000 (Future Vision)

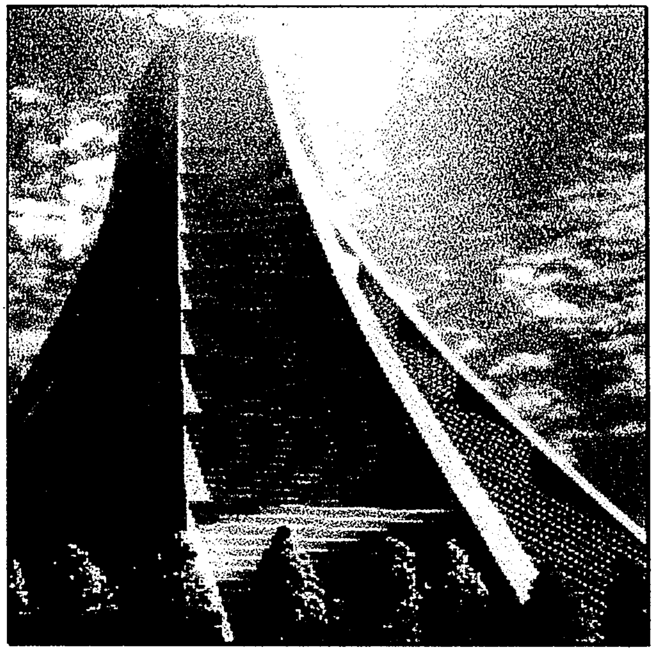

Fig. 4.4 Sky City 1000 (Future Vision)

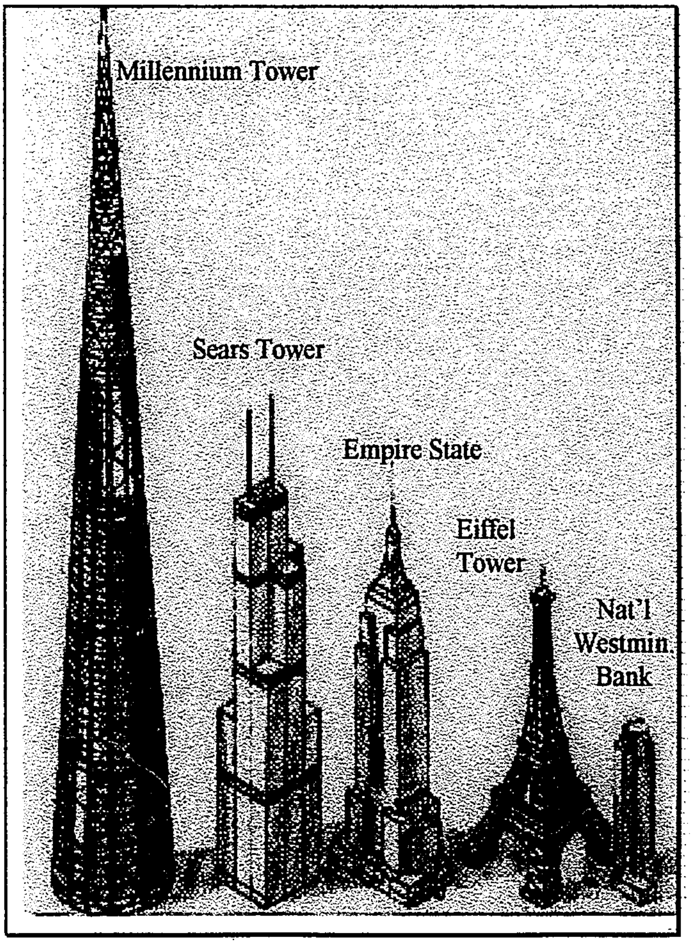

Fig. 4.5 Tokyo Millennium Tower (Future Vision)

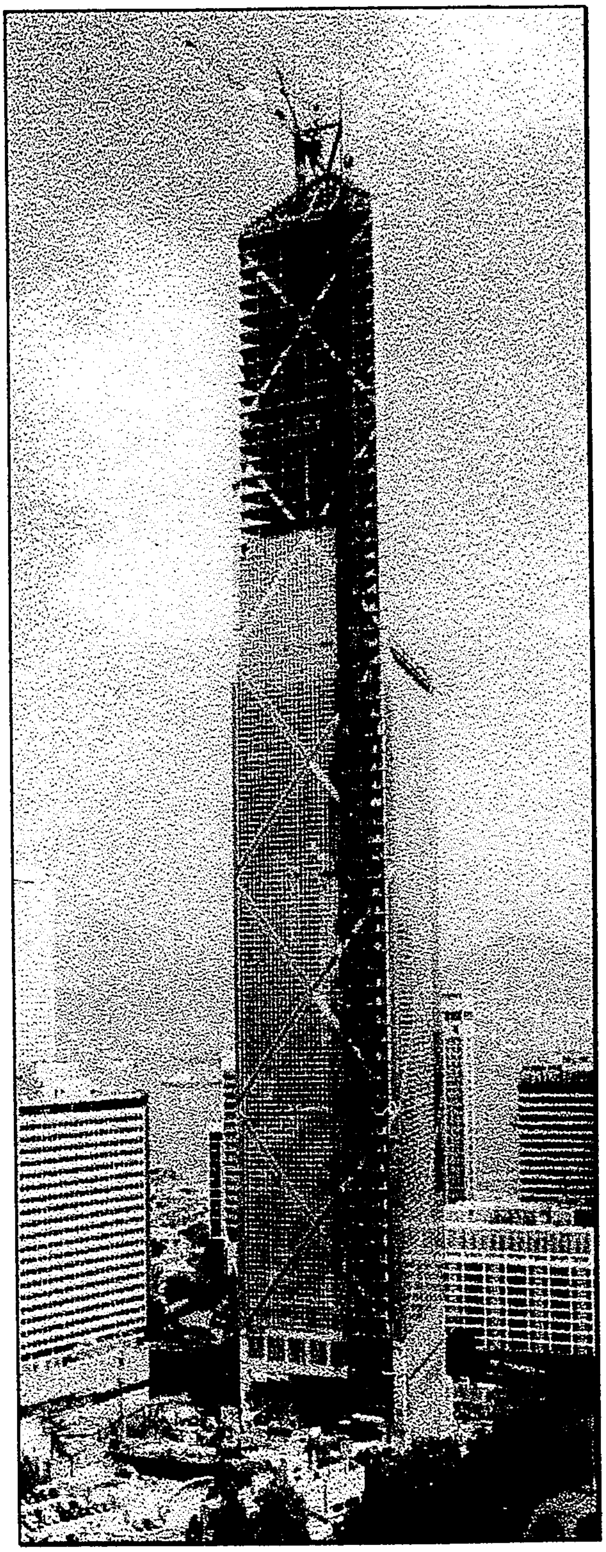

Fig 6.1 Bank of China, ~~Hong~~ Kong
(Trussed Tube)

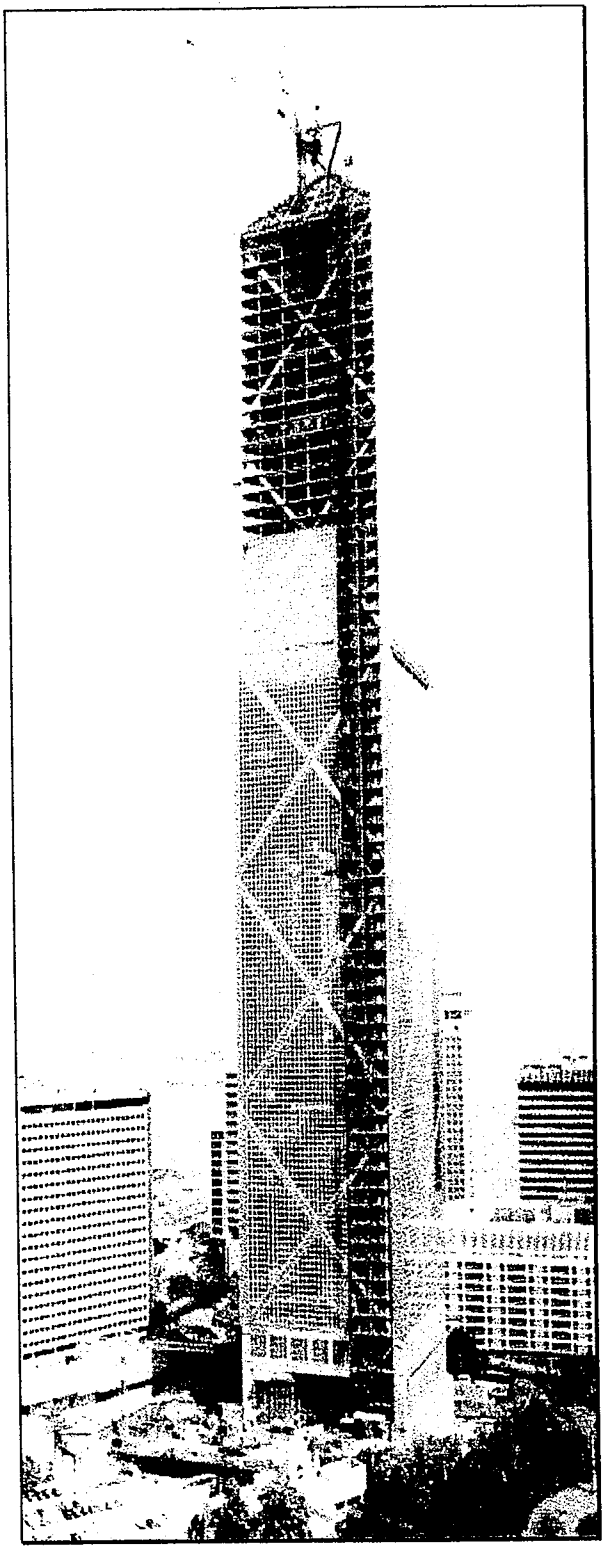

Fig 6.1 Bank of China, Hong Kong
(Trussed Tube)

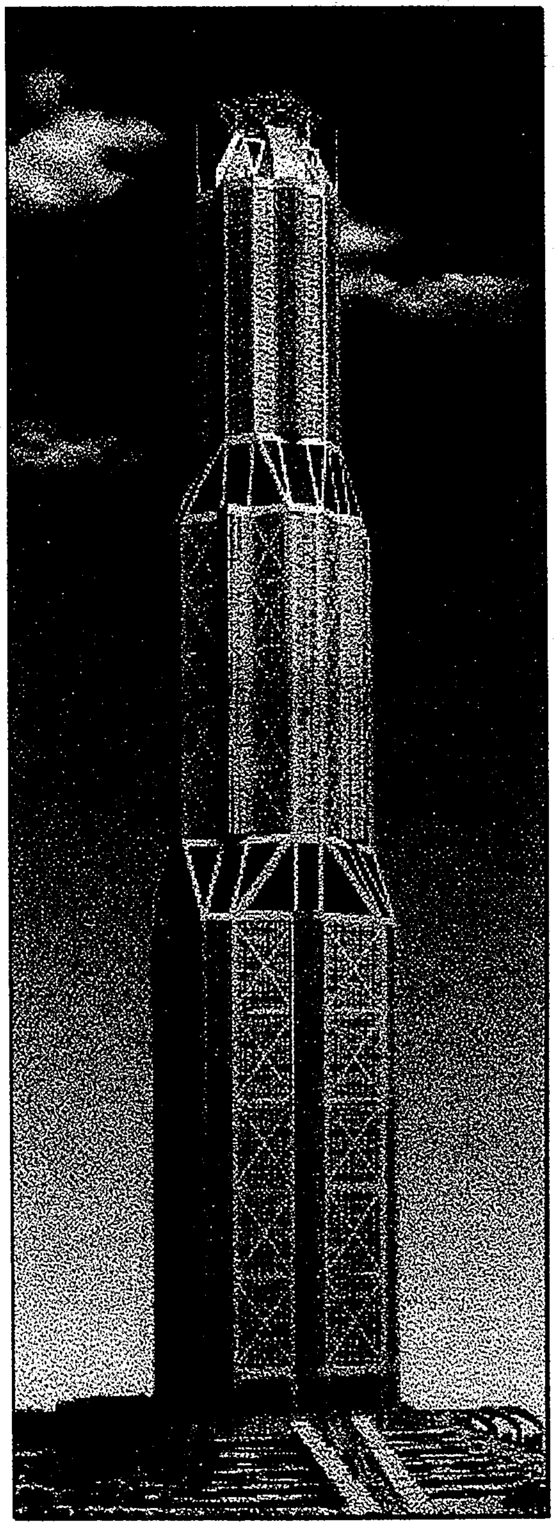

Fig 6.2 Shimuzu Super High-Rise
(Megastructure)

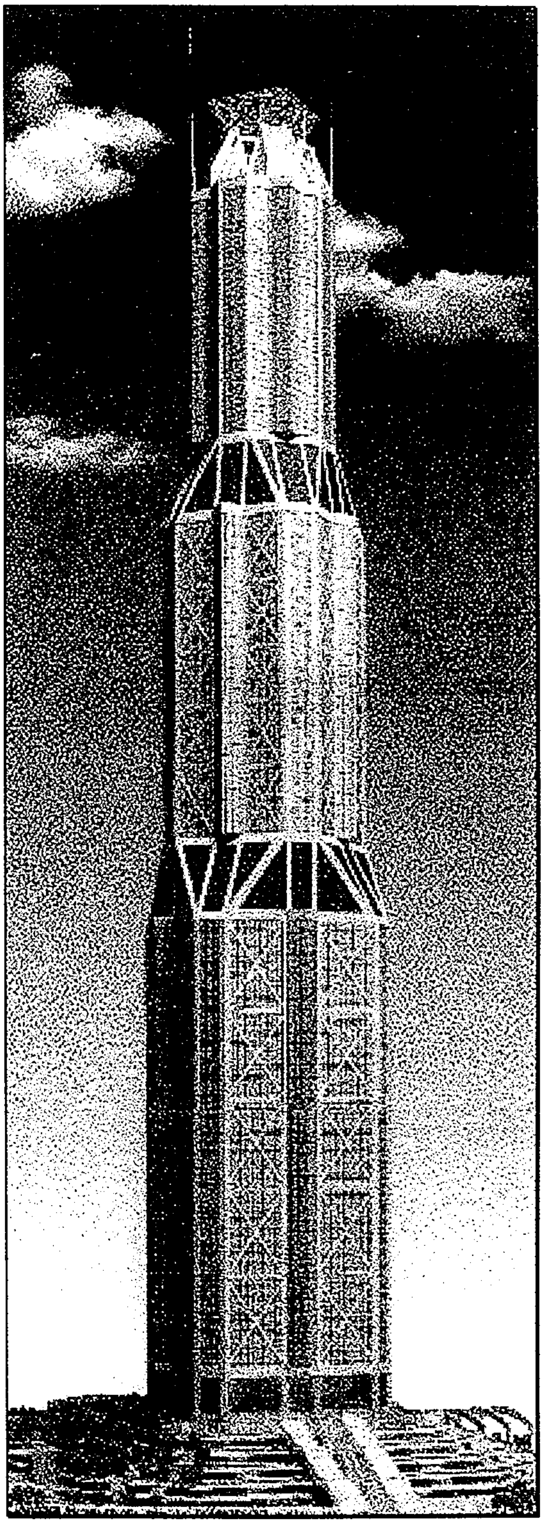

Fig 6.2 Shimuzu Super High-Rise
(Megastructure)

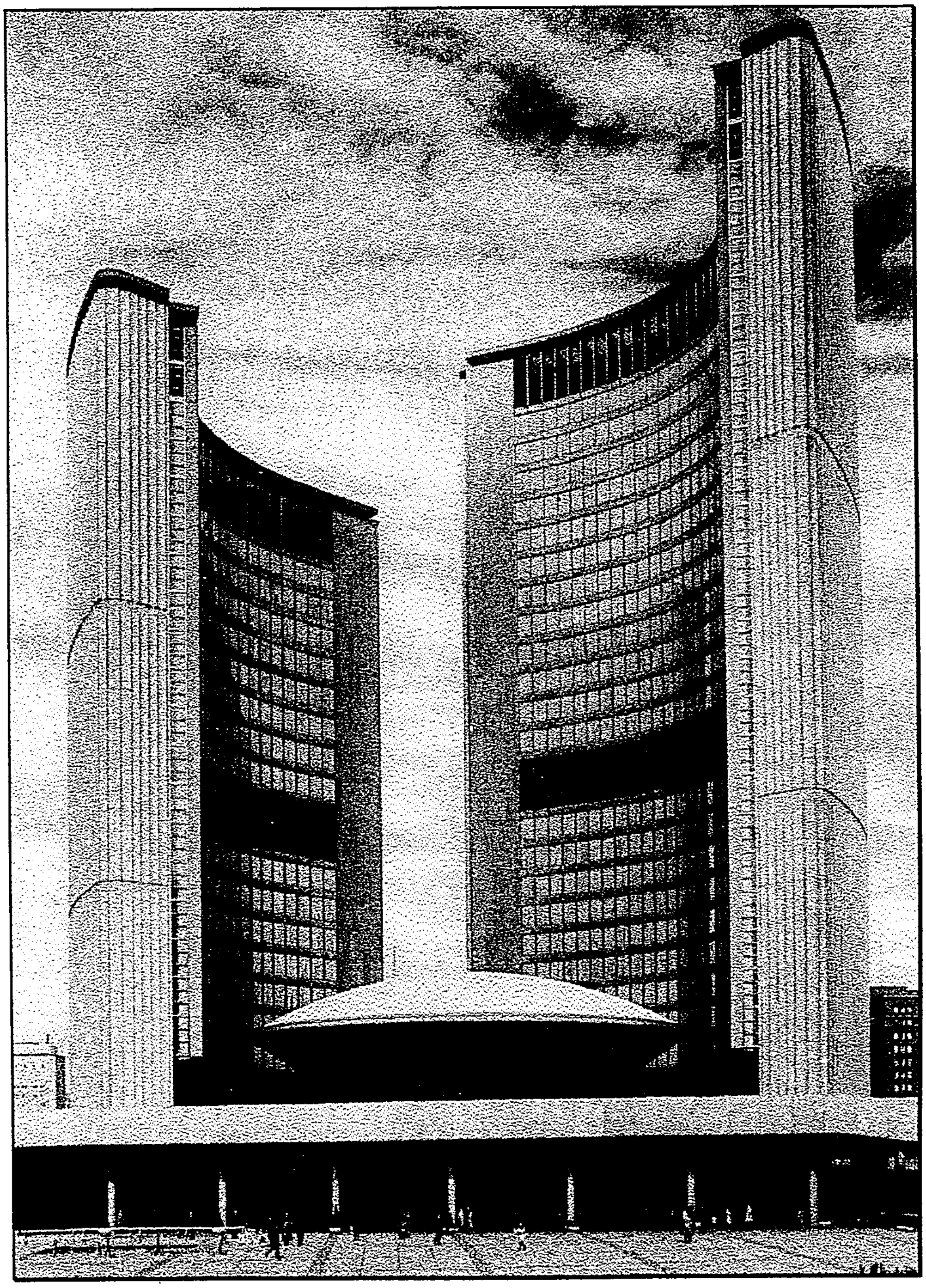

Fig 7.1 Toronto City Hall, Toronto
(Exterior Shear Wall)

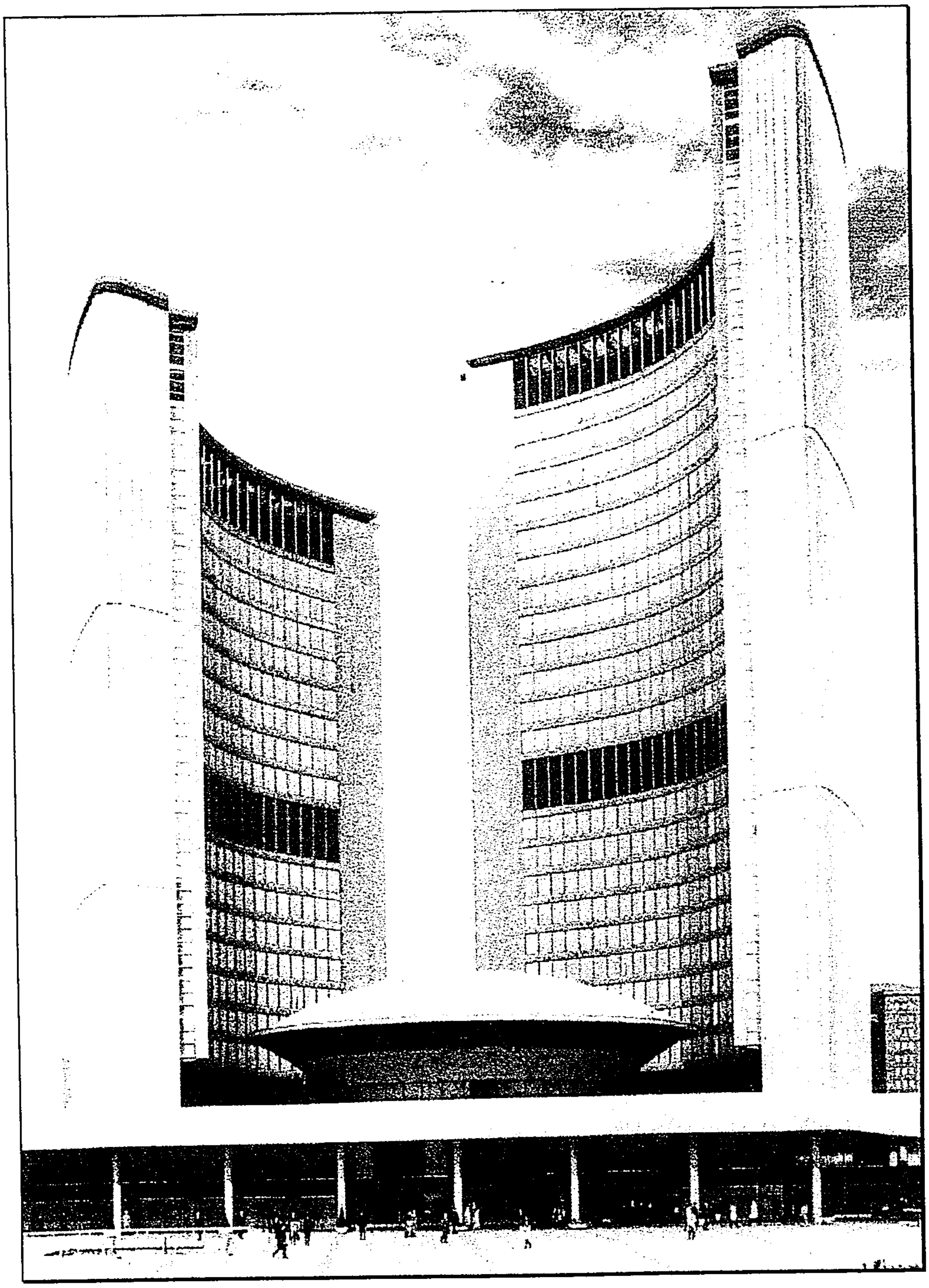

Fig 7.1 Toronto City Hall, Toronto
(Exterior Shear Wall)

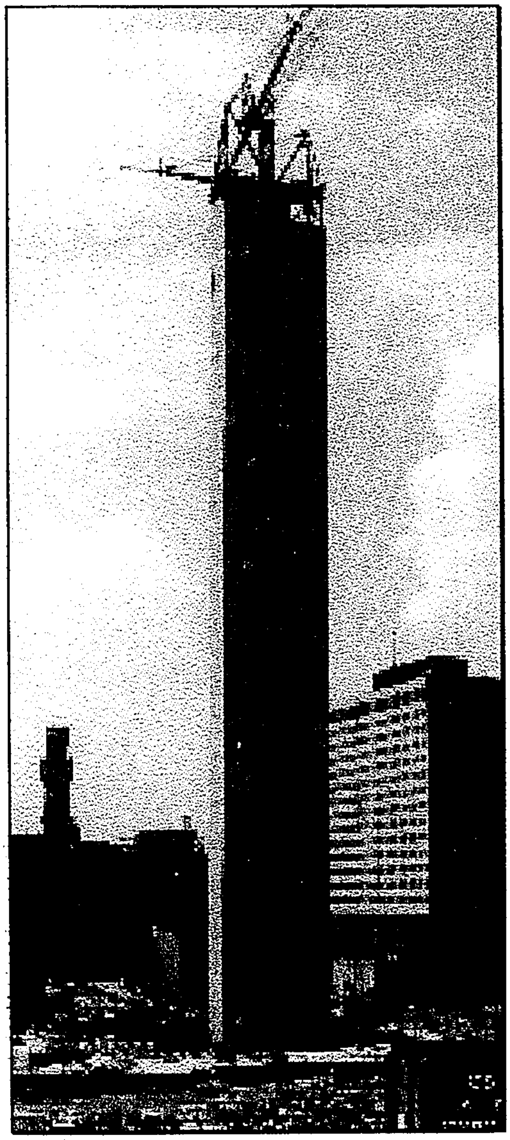

Fig 7.2 First Fidelity Building, Baltimore
(Interior Core)

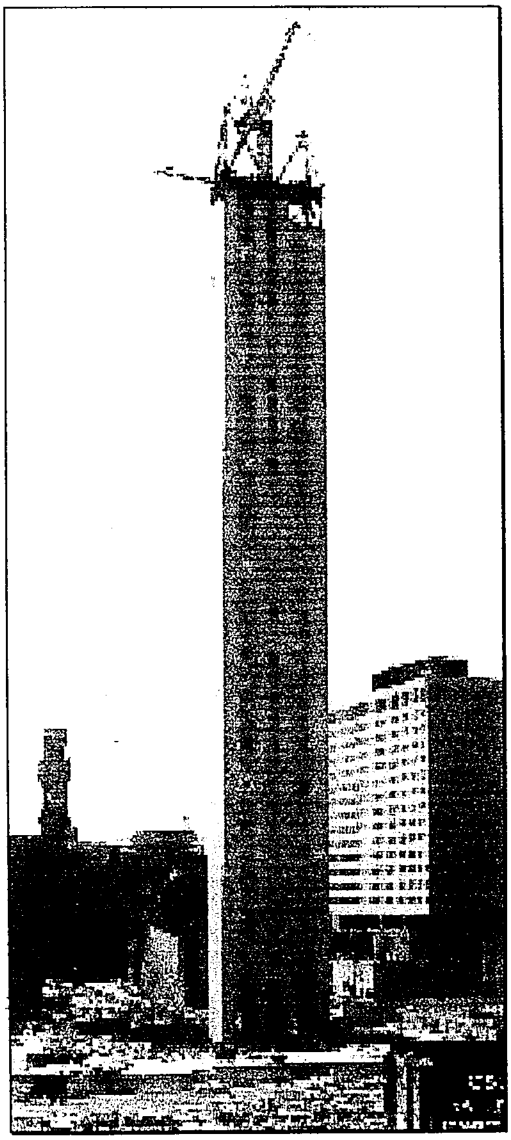

Fig 7.2 First Fidelity Building, Baltimore
(Interior Core)

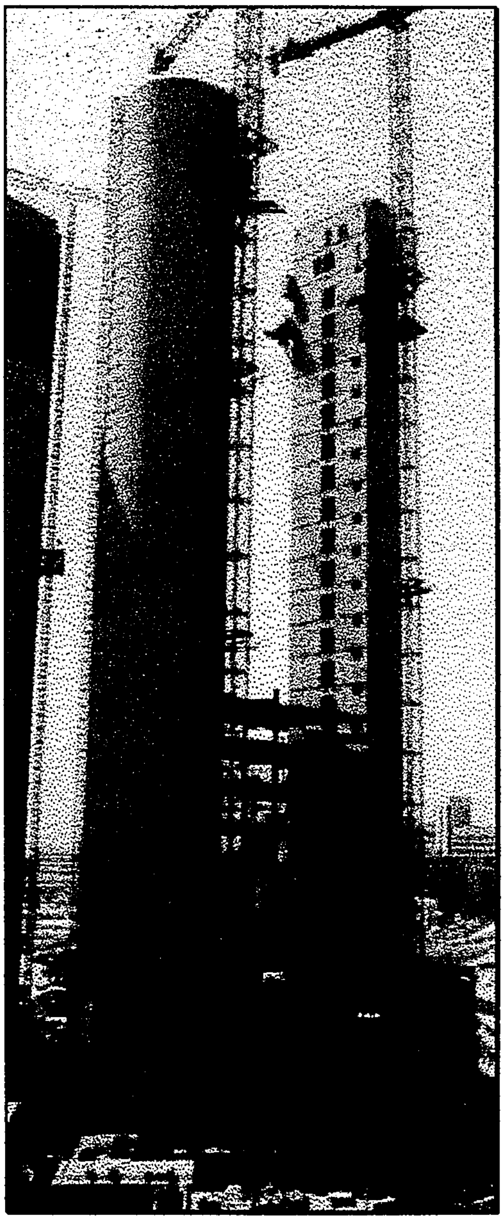

Fig 7.3 Al Ahli, Kuwait
(Two End Cores)

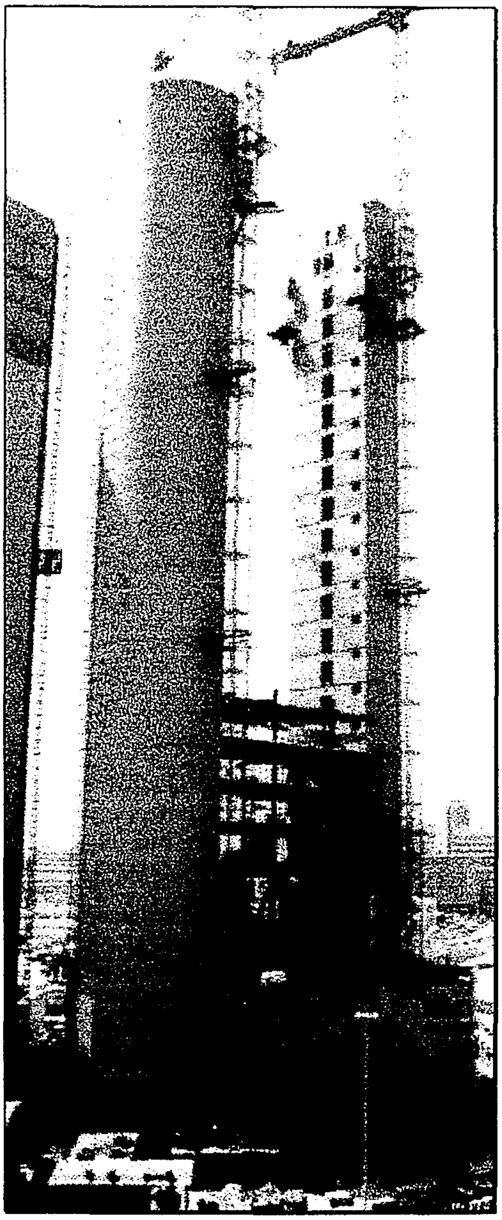

Fig 7.3 Al Ahli, Kuwait
(Two End Cores)

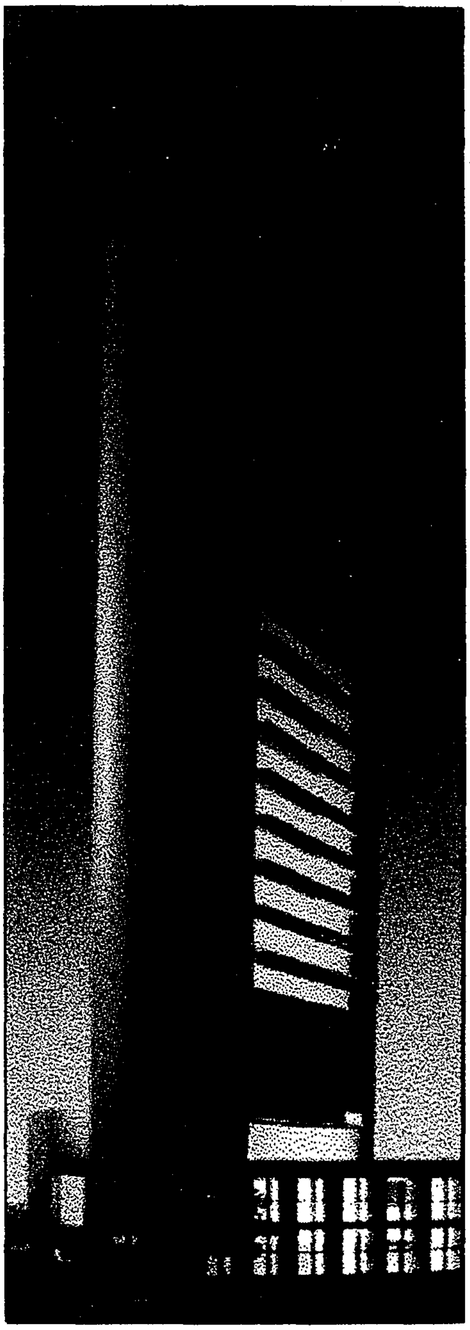

Fig 7.4 Al Ahli, Kuwait
(Two End Cores)

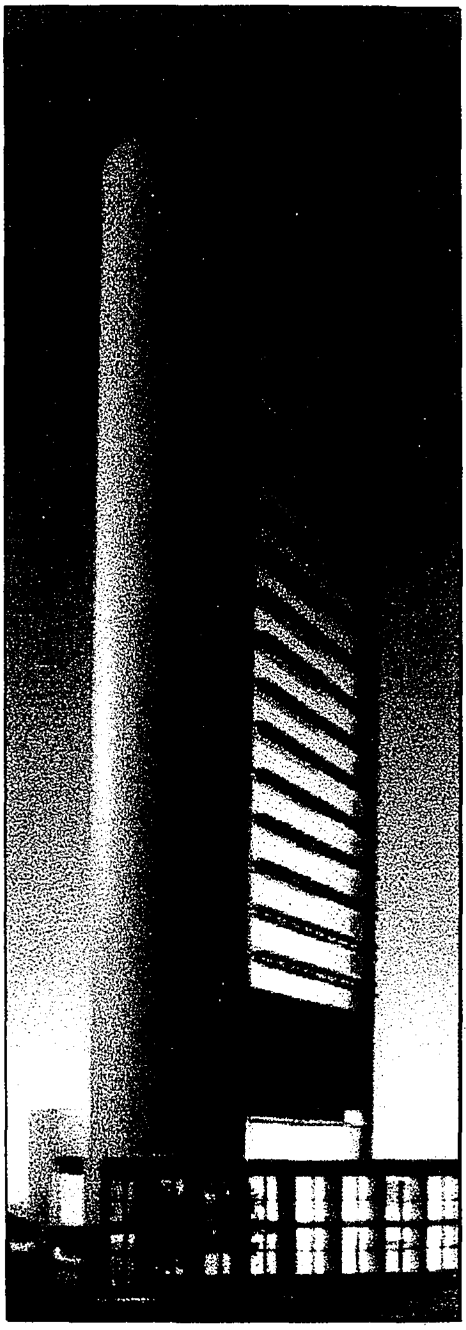

Fig 7.4 Al Ahli, Kuwait
(Two End Cores)

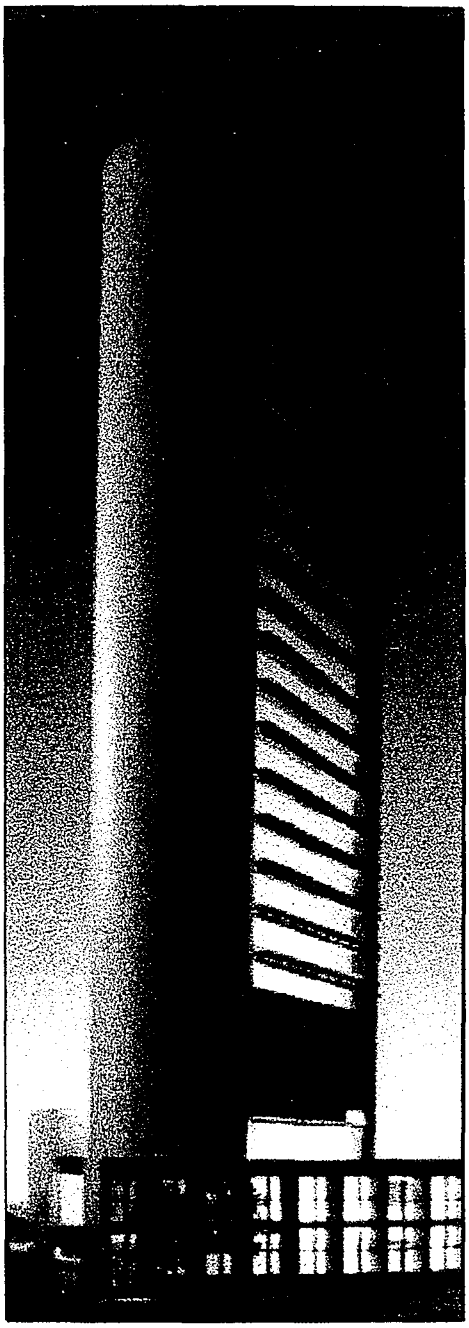

Fig 7.4 Al Ahli, Kuwait
(Two End Cores)

Fig 7.5 Knights of Columbus, New Haven
(Interior and Four Corner Cores)

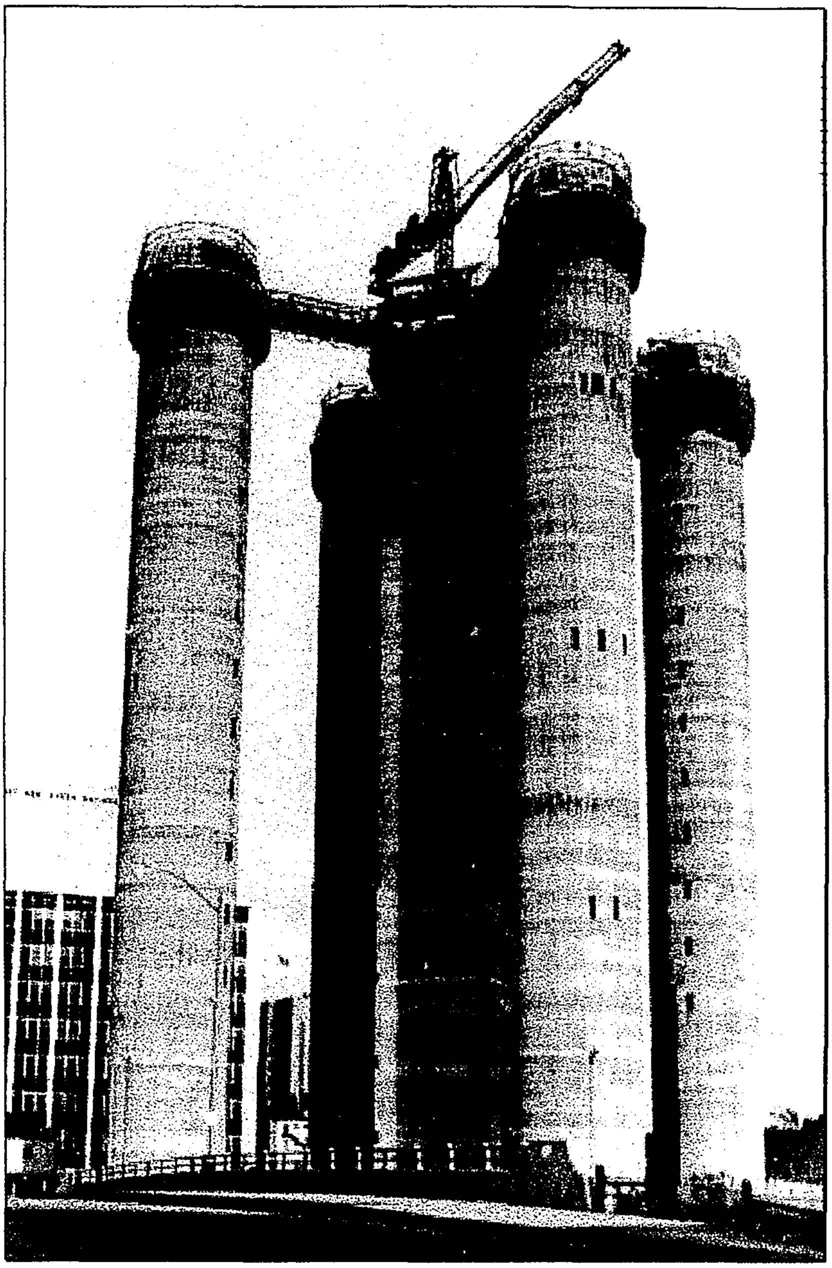

Fig 7.5 Knights of Columbus, New Haven
(Interior and Four Corner Cores)

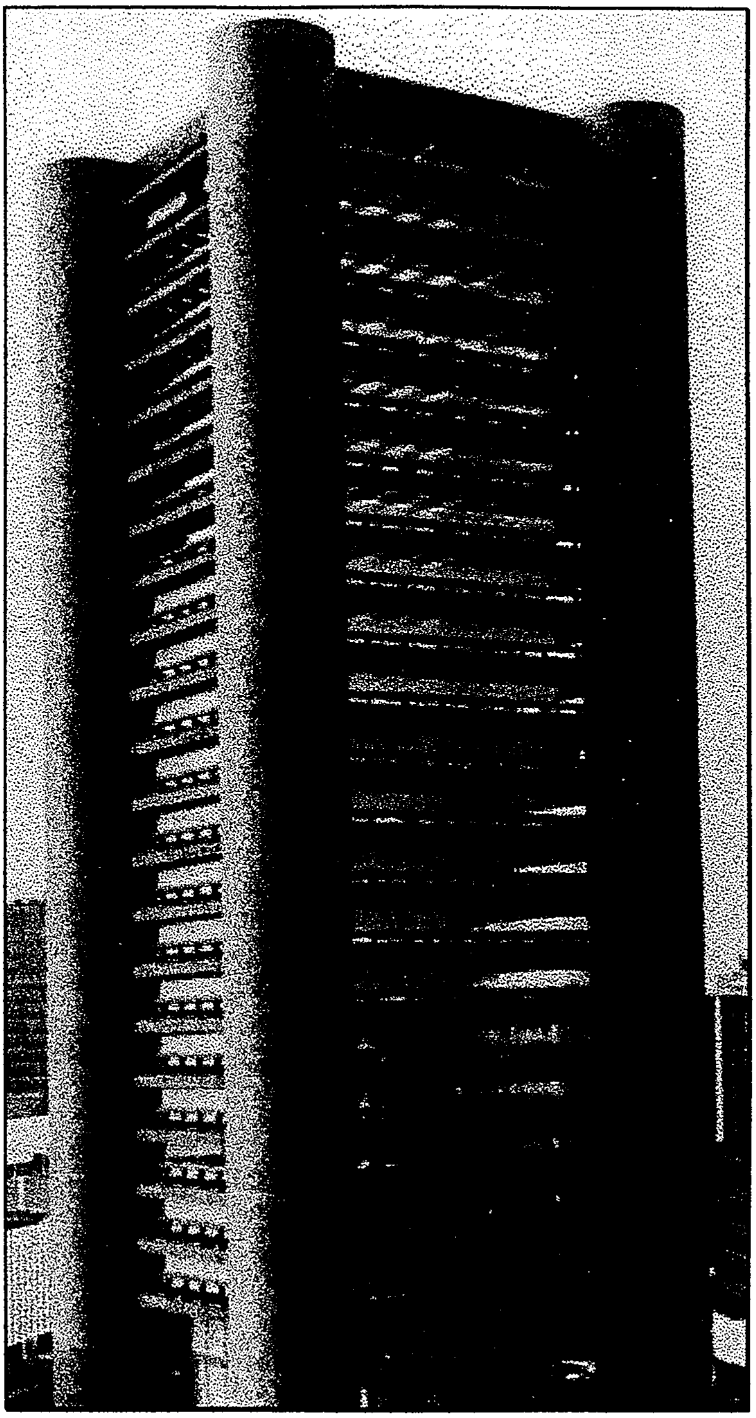

Fig 7.6 Knights of Columbus, New Haven
(Interior and Four Corner Cores)

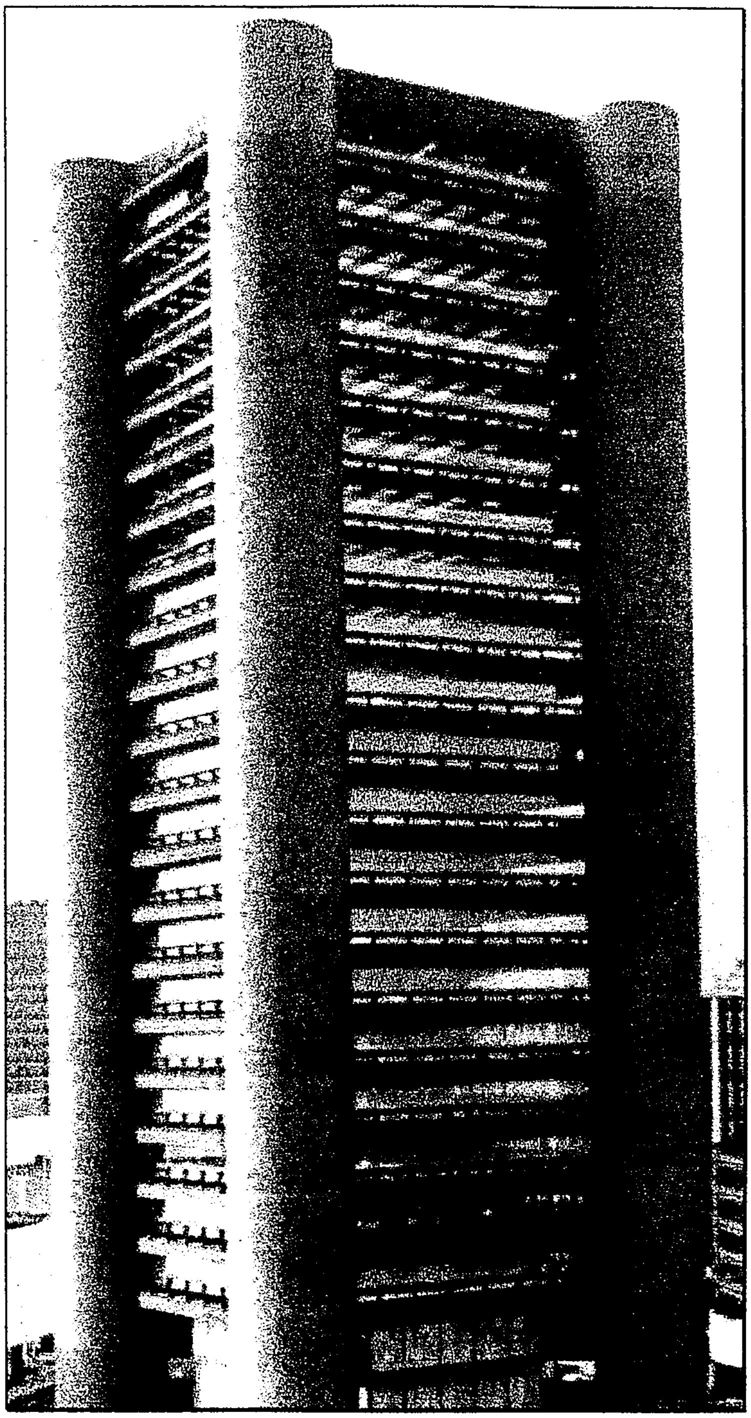

Fig 7.6 Knights of Columbus, New Haven
(Interior and Four Corner Cores)

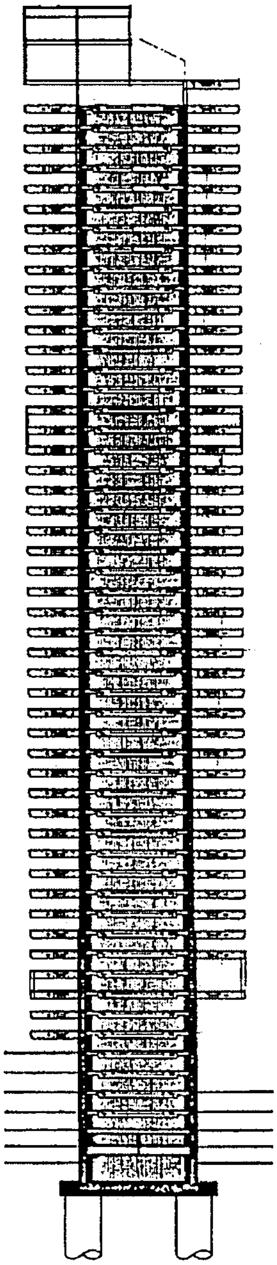

Fig 7.7 Treasury Building - Section, Singapore
(Interior Core with Cantilevered Floors)

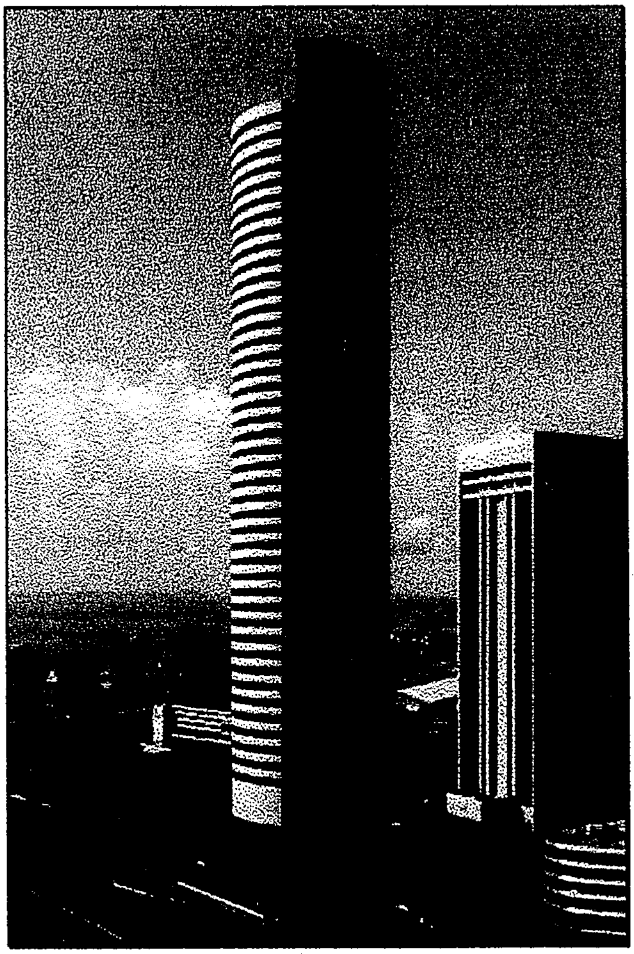

Fig 7.8 Treasury Building, Singapore
(Interior Core with Cantilevered Floors)

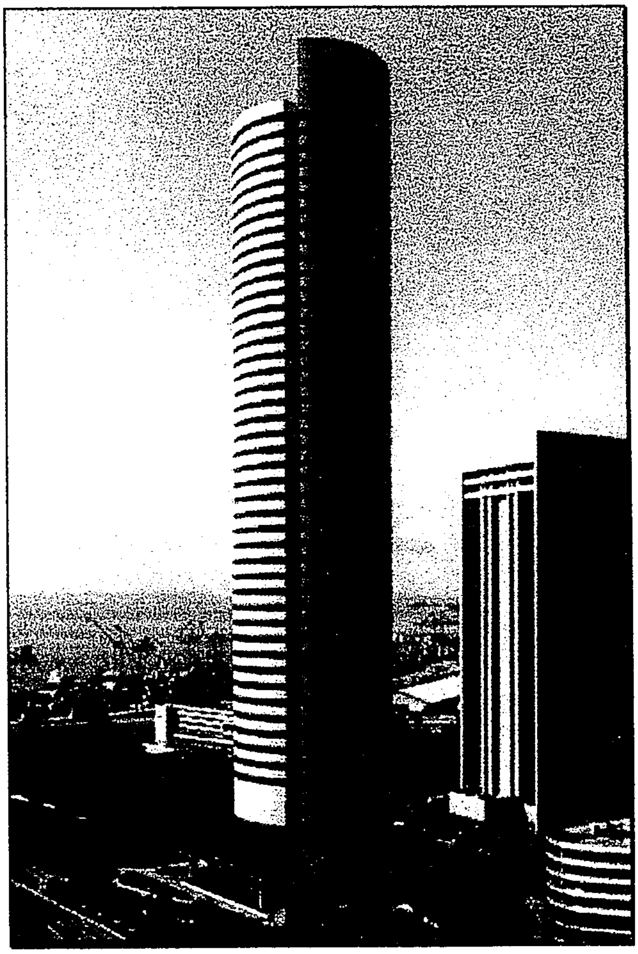

Fig 7.8 Treasury Building, Singapore
(Interior Core with Cantilevered Floors)

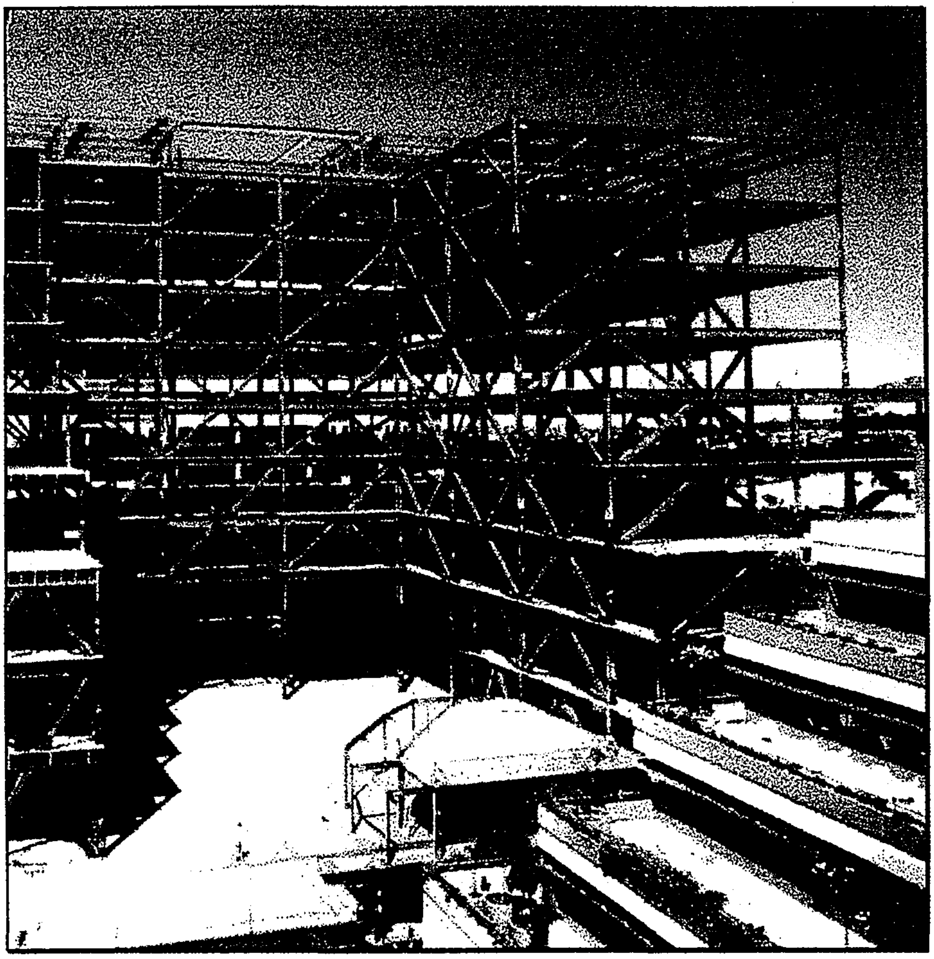

Fig 7.9 California Plaza, Walnut Creek
(Braced Frame)

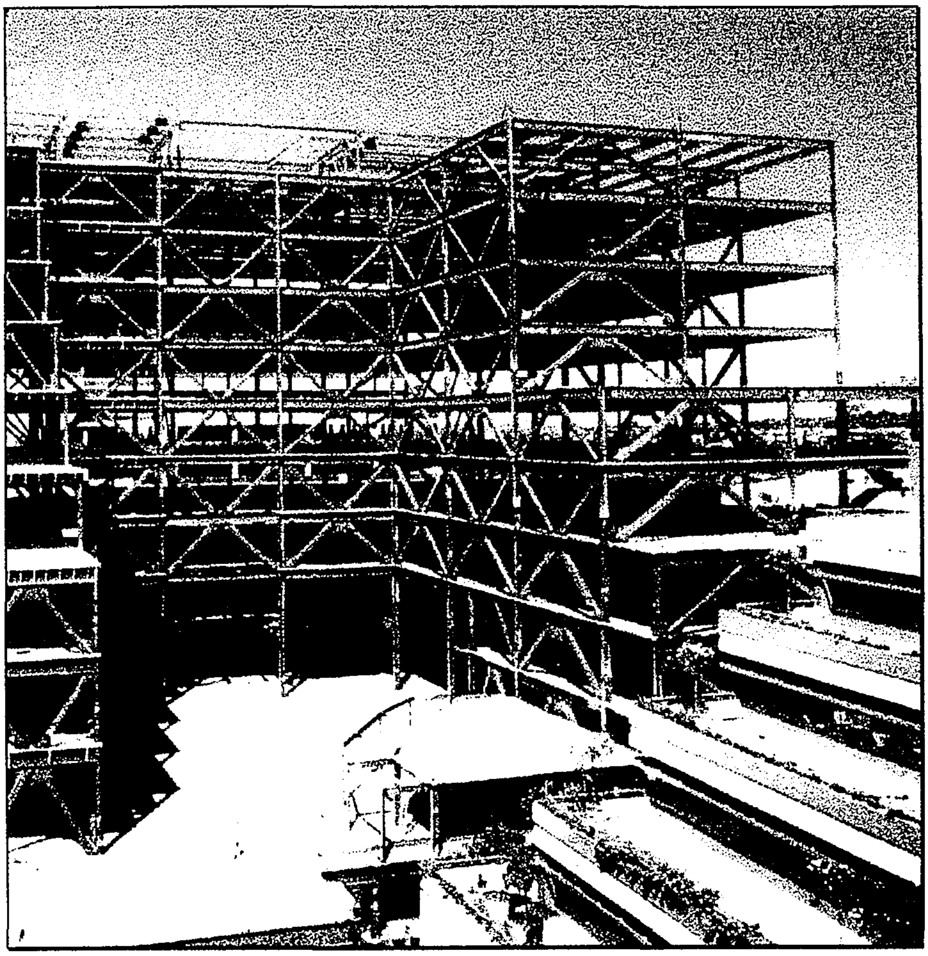

Fig 7.9 California Plaza, Walnut Creek
(Braced Frame)

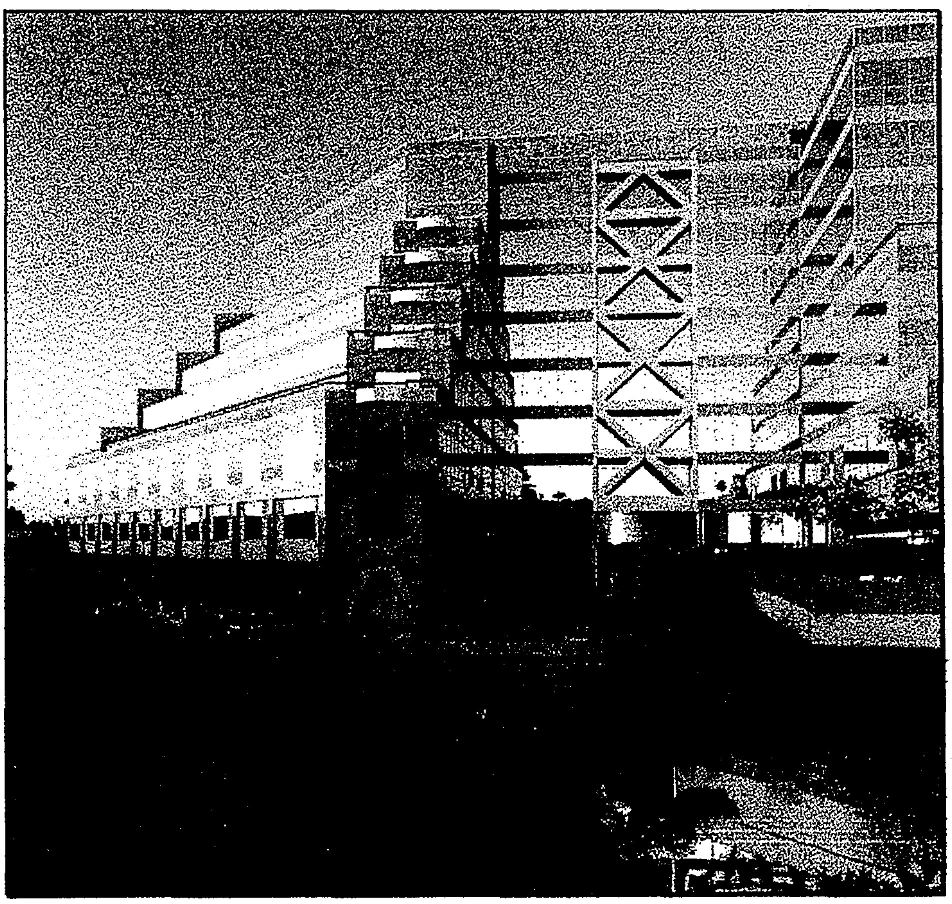

Fig 7.10 California Plaza, Walnut Creek
(Braced Frame)

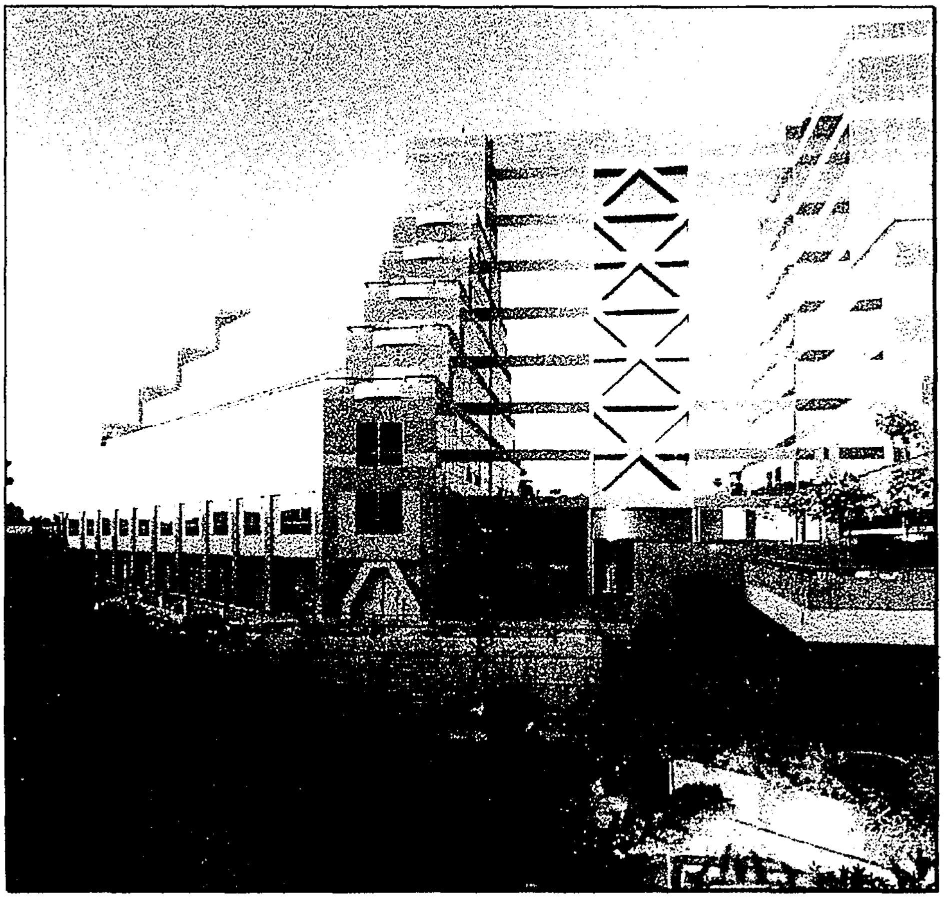

Fig 7.10 California Plaza, Walnut Creek
(Braced Frame)

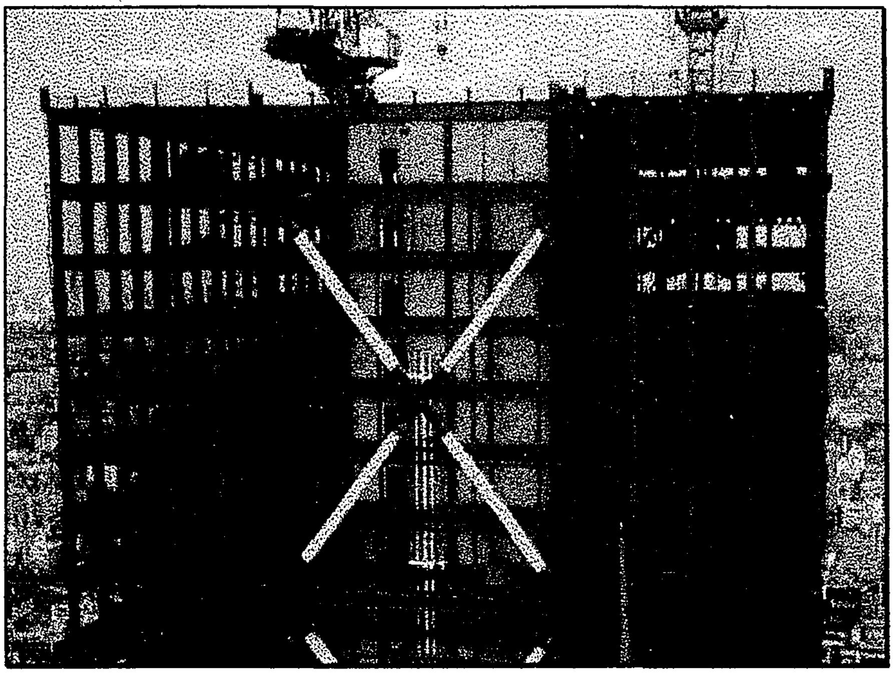

Fig 7.11 Mitsui Building, Japan
(Moment Resisting Frame)

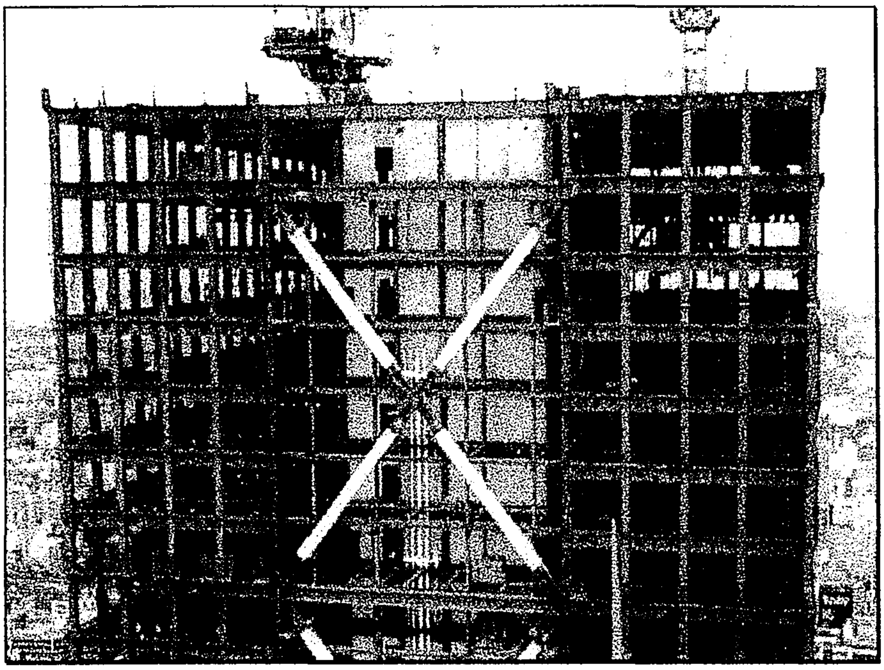

Fig 7.11 Mitsui Building, Japan
(Moment Resisting Frame)

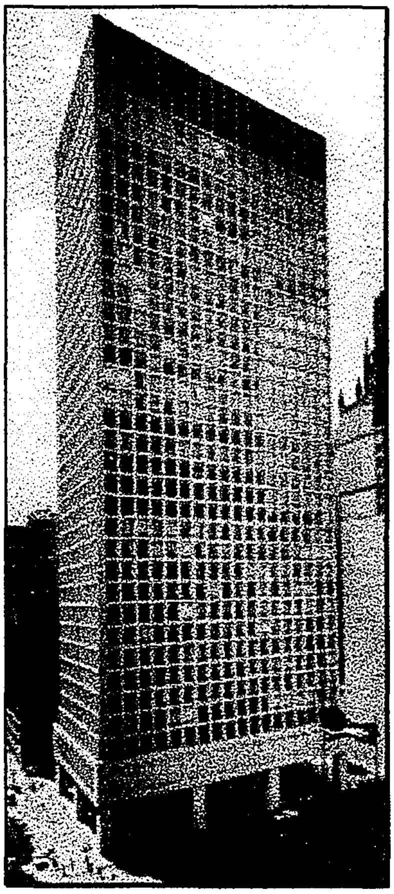

Fig 7.12 Brunswick, Chicago
(Framed Tube)

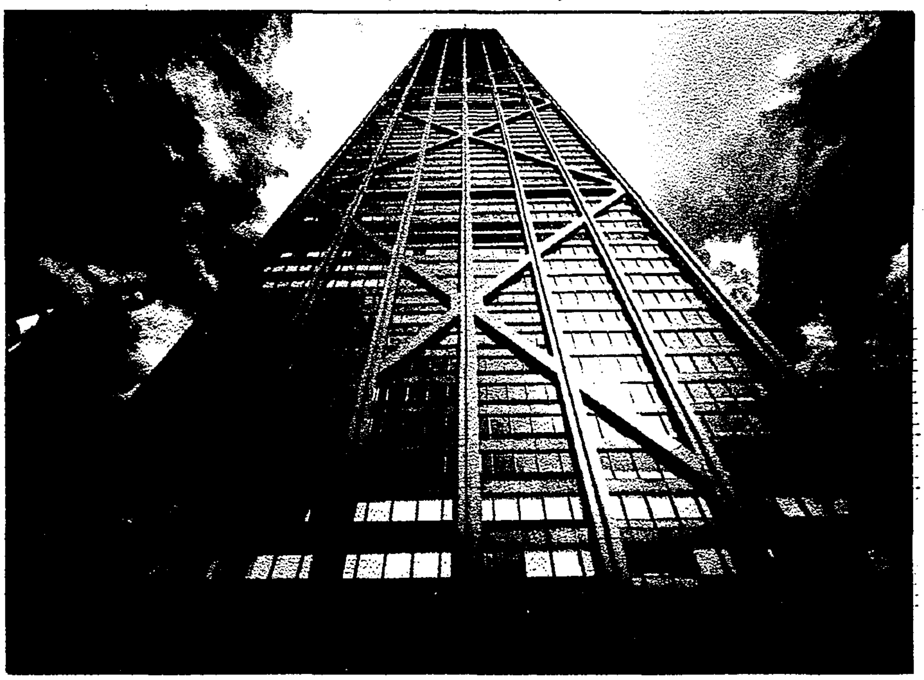

Fig 7.13 John Hancock, Chicago
(Trussed Tube)

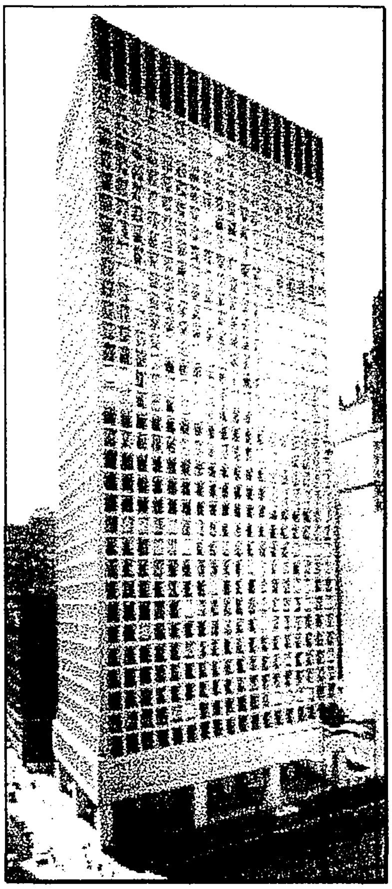

Fig 7.12 Brunswick, Chicago
(Framed Tube)

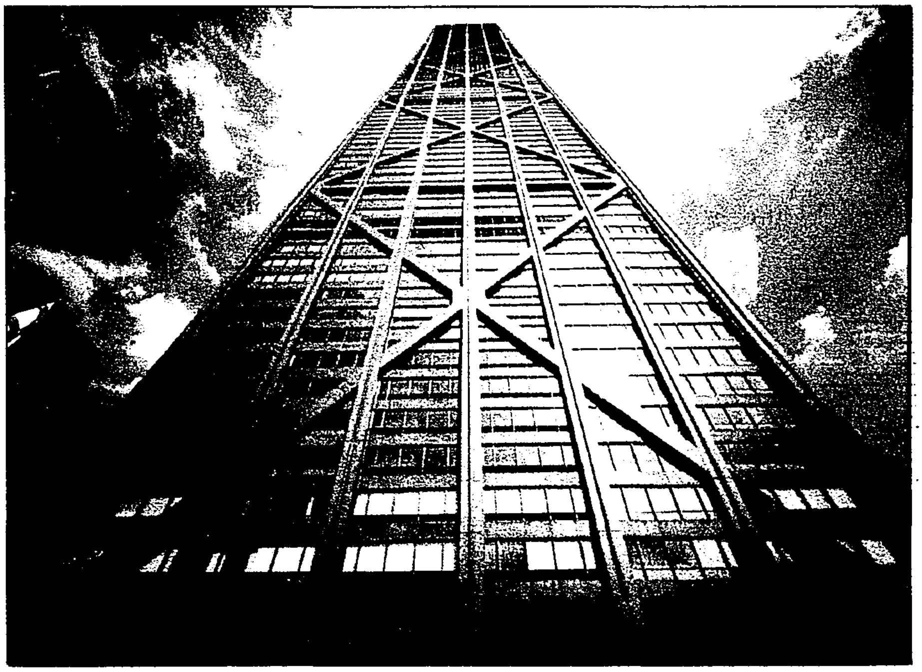

Fig 7.13 John Hancock, Chicago
(Trussed Tube)

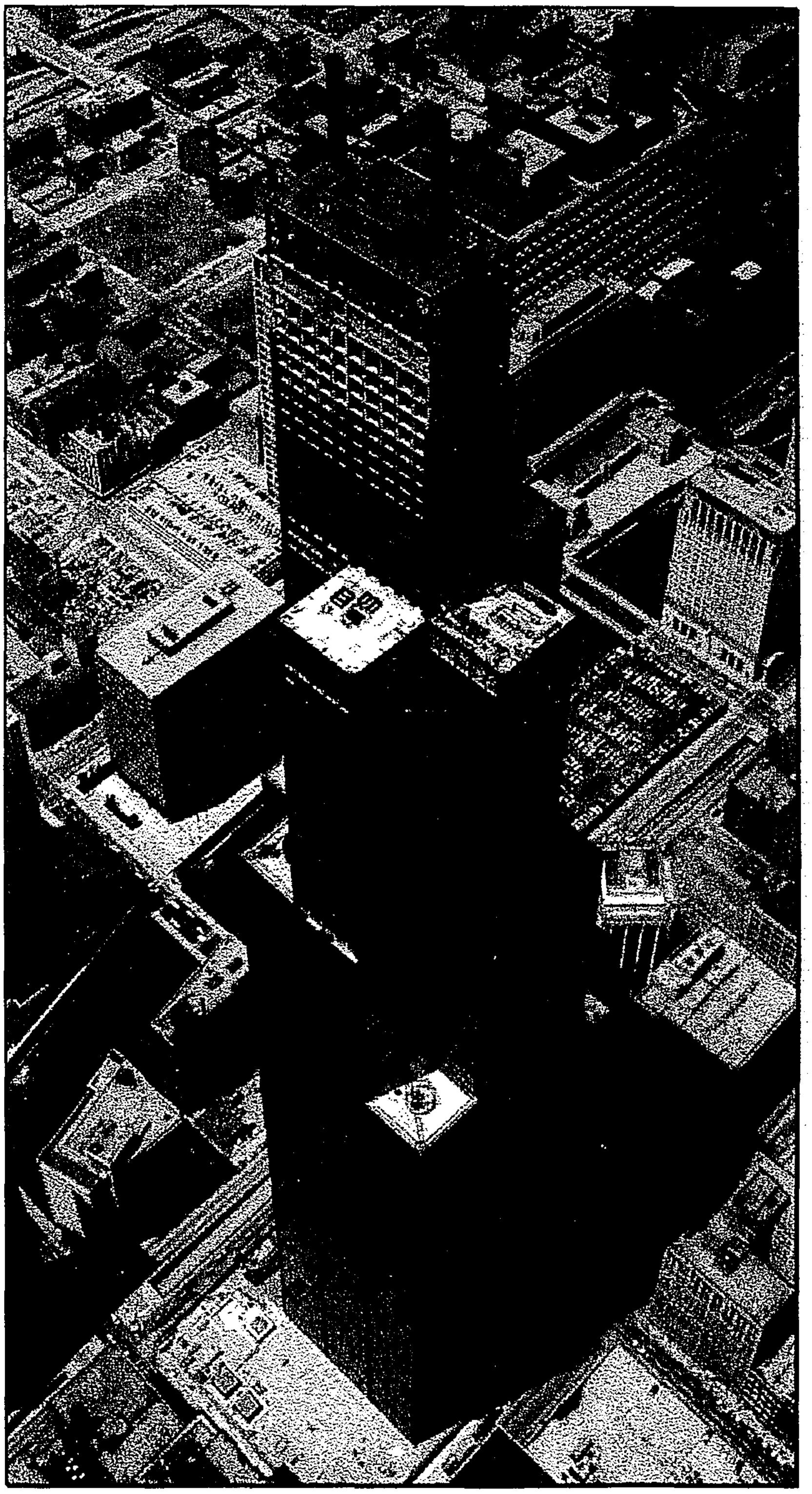

Fig 7.14 Sears Tower, Chicago
(Bundled Tube)

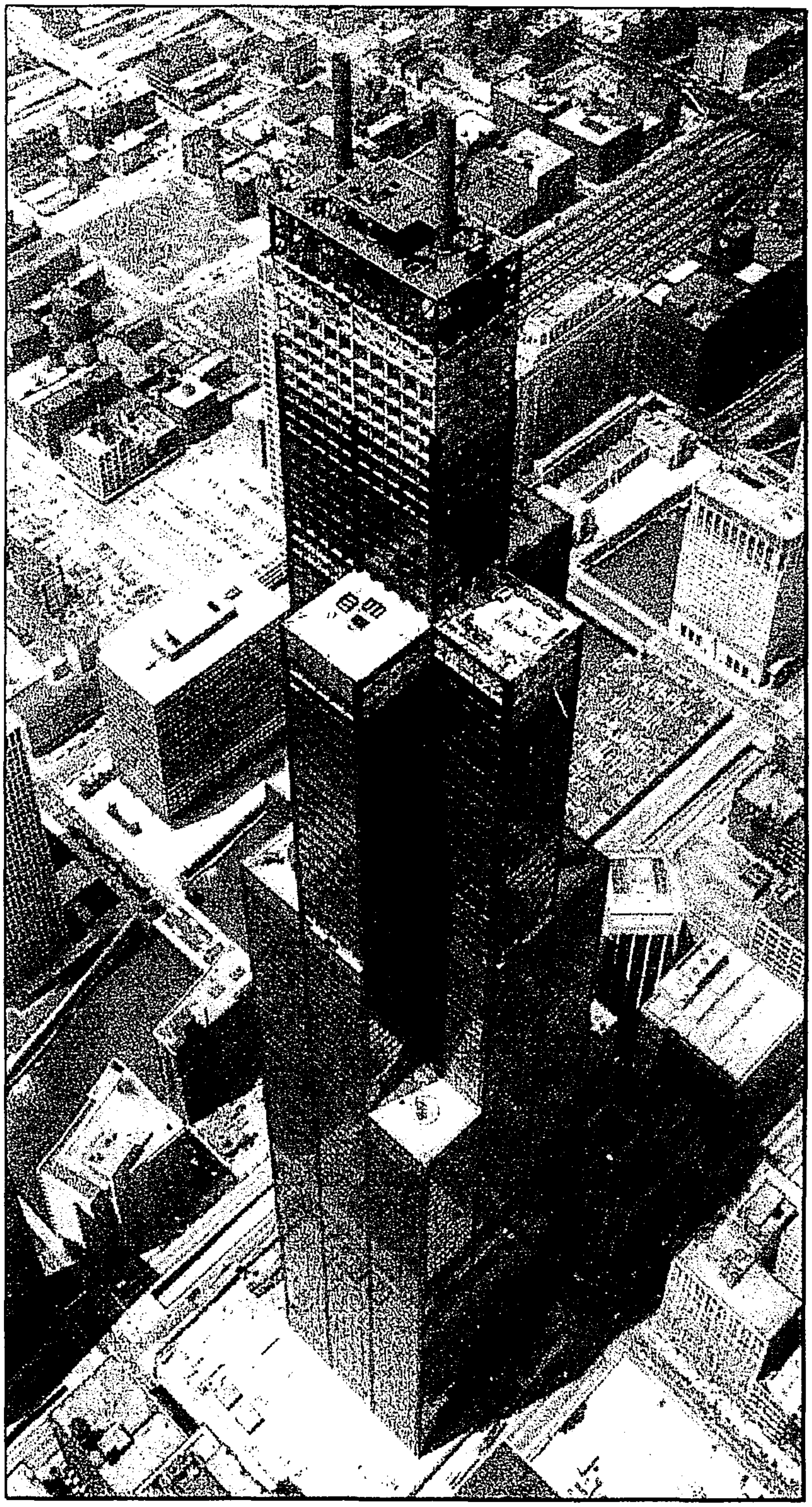

Fig 7.14 Sears Tower, Chicago
(Bundled Tube)

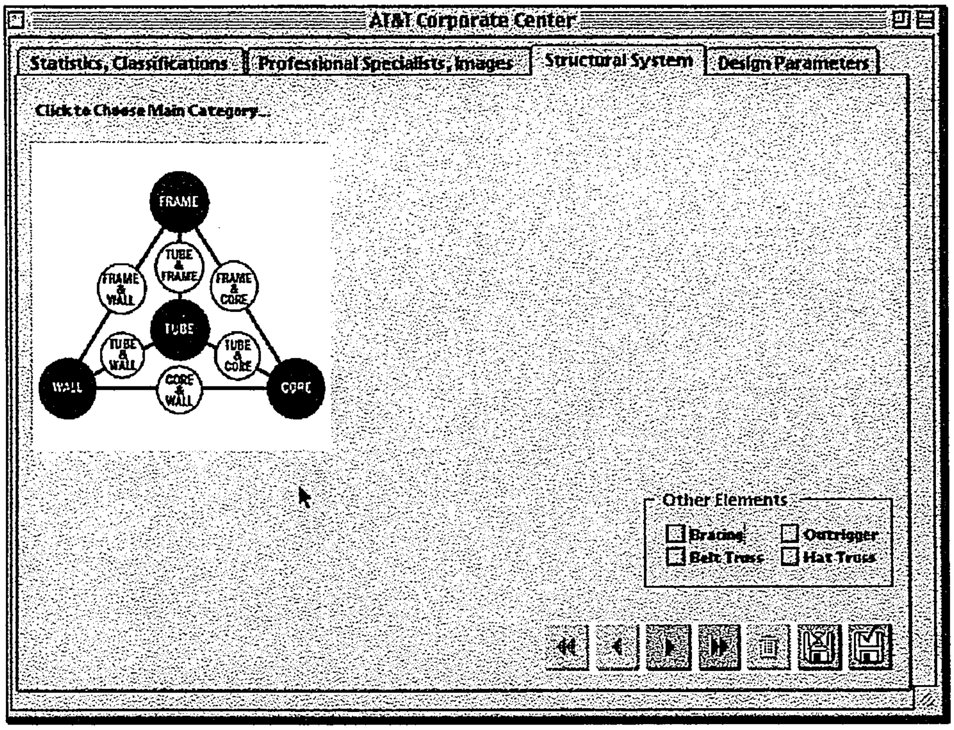

Fig 8.1 HRBD Building Record - Structural Systems

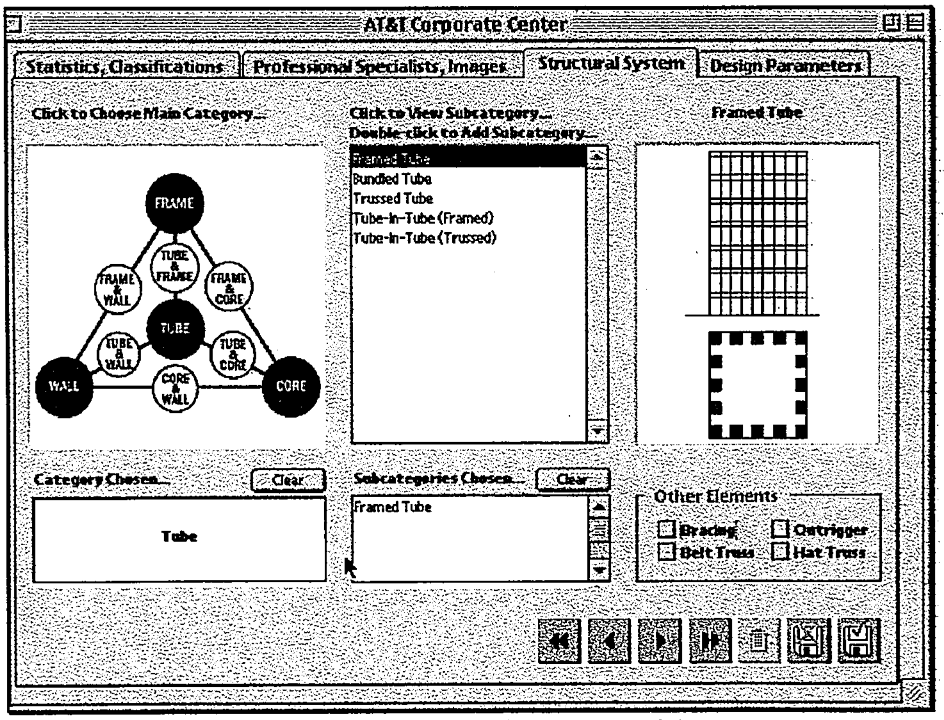

Fig. 8.2 HRBD Building Record - Structural Systems Input

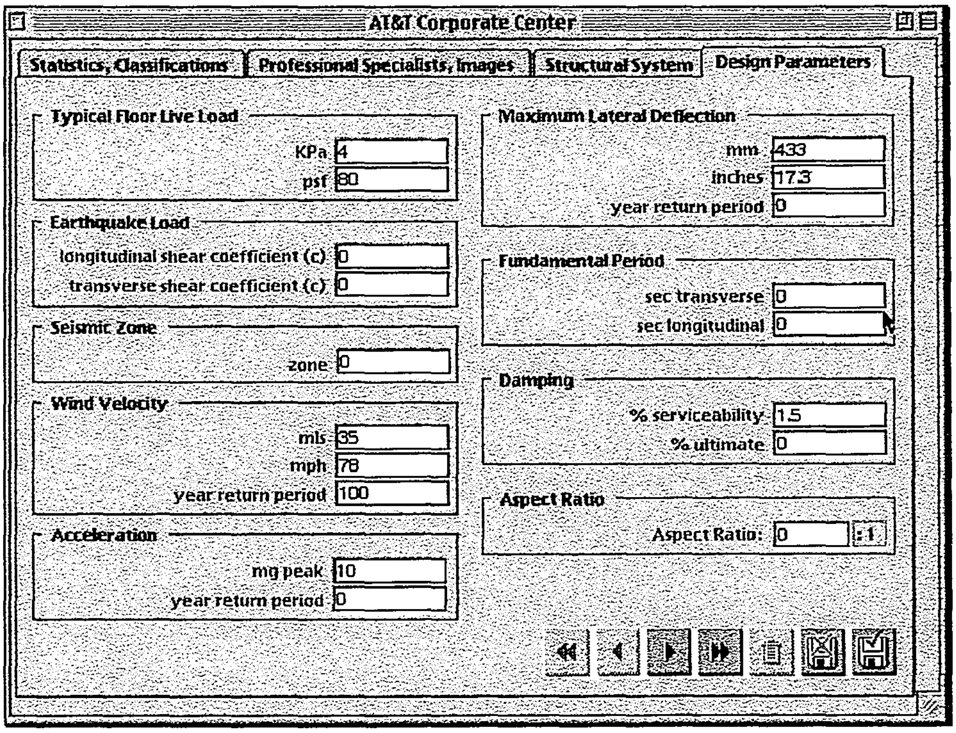

Fig 8.3 HRBD Design Parameters

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Vita

Cynthia T. Bruno, daughter of Ennio and Elisa (Carbone) Bruno, was born on August 2, 1974 in Norristown, Pennsylvania. After graduating from Bishop Kenrick High School in 1992, she continued her education by attending Lehigh University. While double majoring in architecture and civil engineering at Lehigh University, she was inducted into Tau Beta Pi (1994), Phi Beta Kappa (1995), Chi Epsilon (1996) and Sigma Xi (1998). Other honors include a Ronald M. Freeman Scholarship (1993-96), a Presidential Scholarship (1996-97), Dean's List, and National Dean's List (1996). As an undergraduate, Cynthia received her Fundamentals of Engineering Certification in the Fall of 1995. In addition, she was employed with the Council on Tall Buildings and Urban Habitat, the Center for Advanced Technology of Large Structural Systems (ATLSS) and OTS of Pennsylvania Telecommunication Contractors. She graduated from Lehigh University with high honors in 1996 and 1997 with a B.S. in Civil Engineering and B.A. in Architecture, respectively.

Cynthia extended her education by remaining at Lehigh University to pursue a Master of Science degree in Civil Engineering. She was appointed a Kahn Fellow and continued her work with the Council on Tall Buildings and Urban Habitat as a Research Assistant. She is currently a member of the Pennsylvania Society of Professional Engineers (Valley Forge Chapter), the National Society of Pennsylvania Engineers and the Council on Tall Buildings and Urban Habitat High-Rise Building Database Committee 14. Upon graduation in the spring of 1998, she plans to pursue a career as a structural engineer with firms located in the Philadelphia metropolitan area.

END

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